

Fig. 1

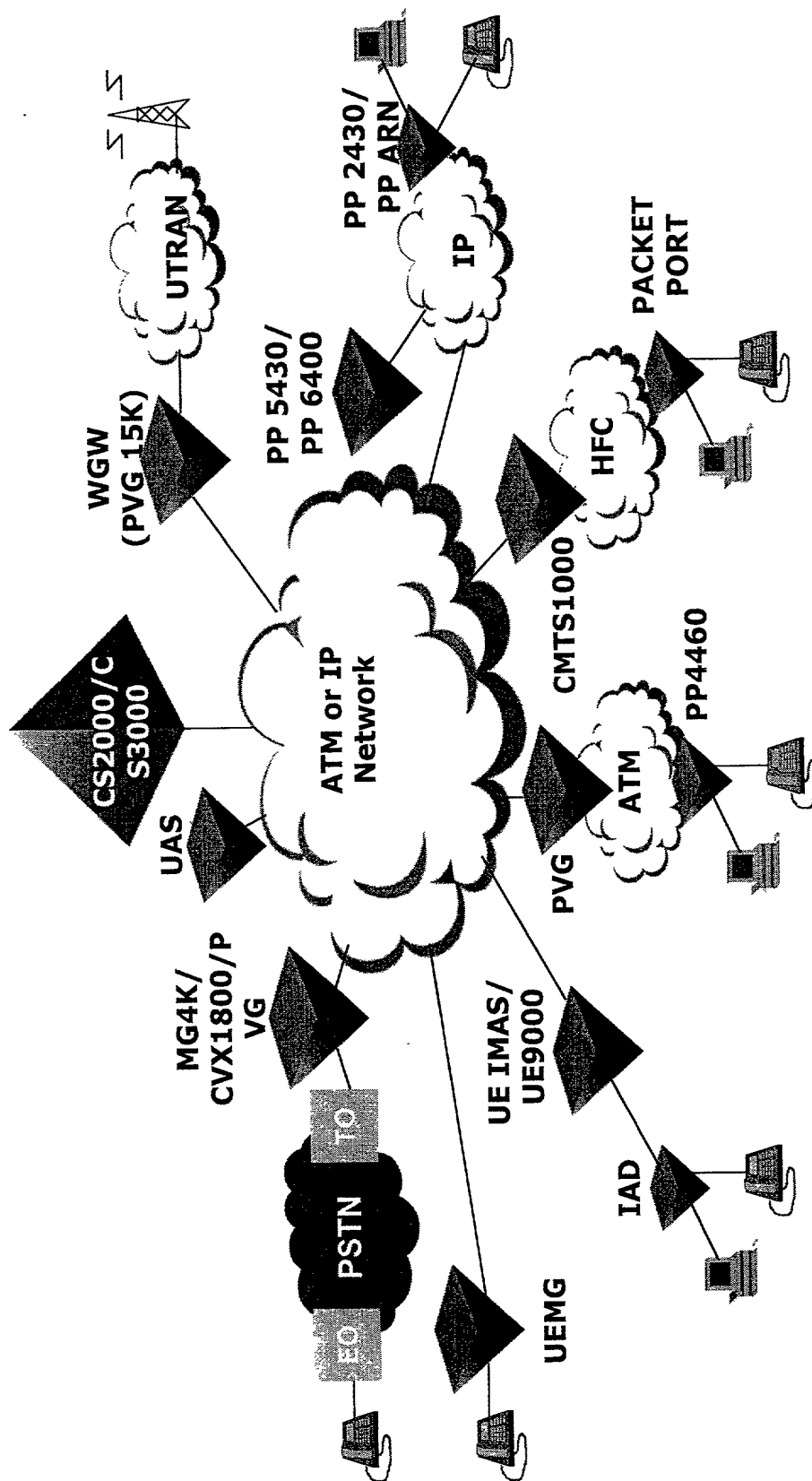


Fig. 2

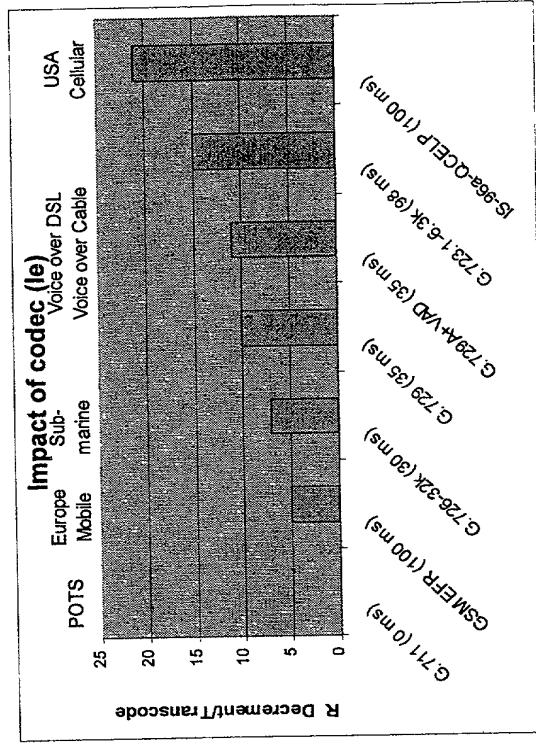
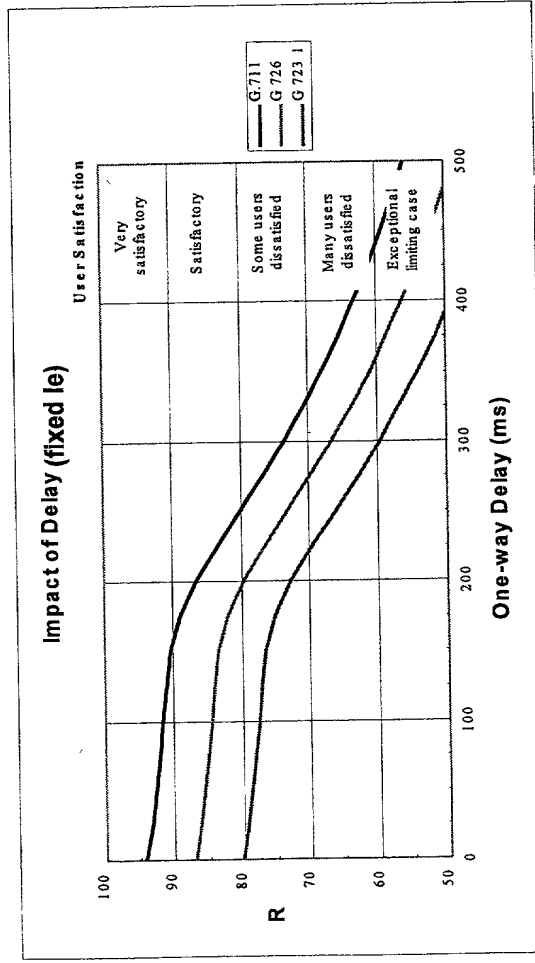


Fig. 3

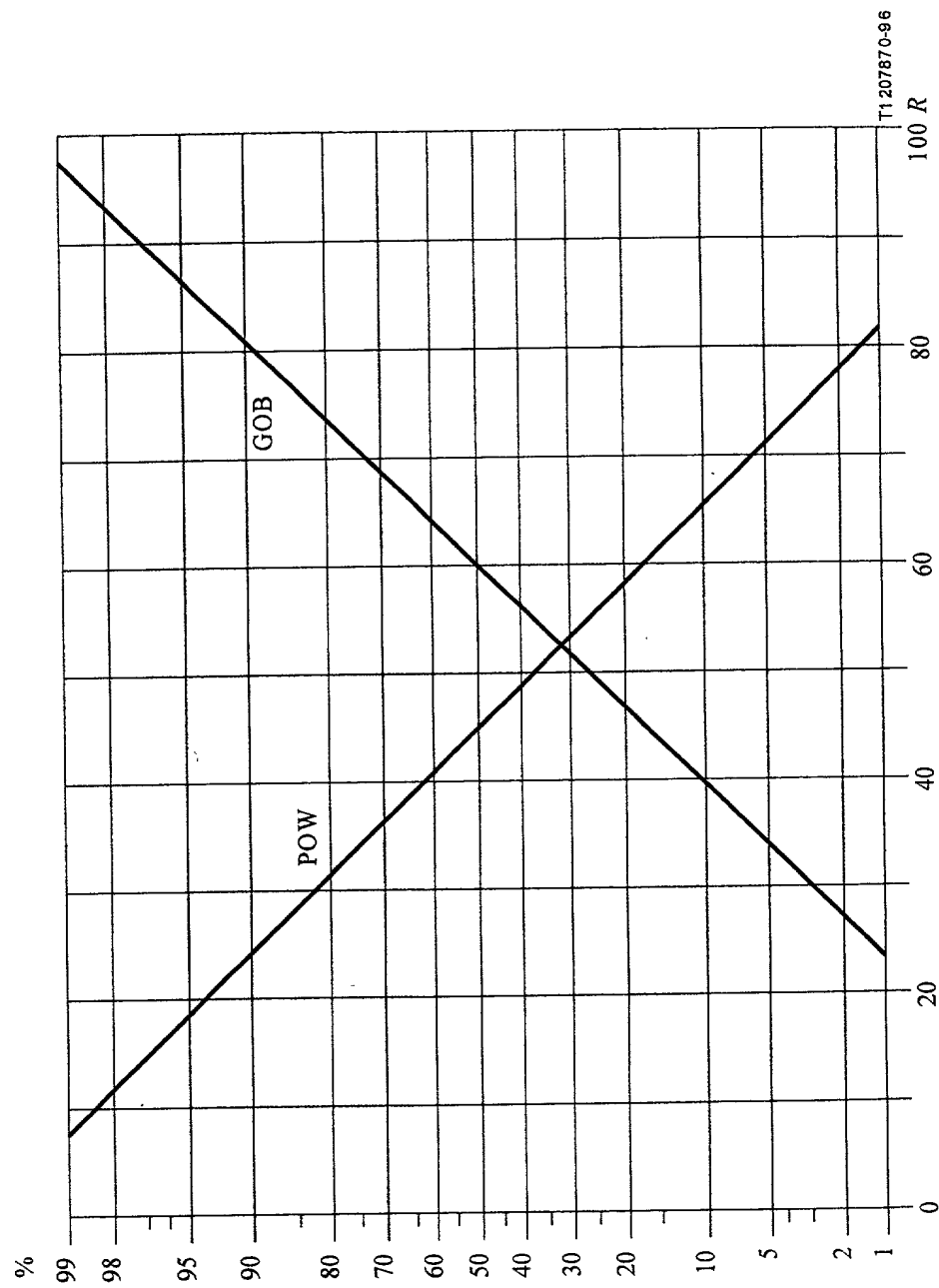


Figure B.1/G.107 - GOB (Good or Better) and POW (Poor or Worse) as functions of rating factor R

Fig. 4

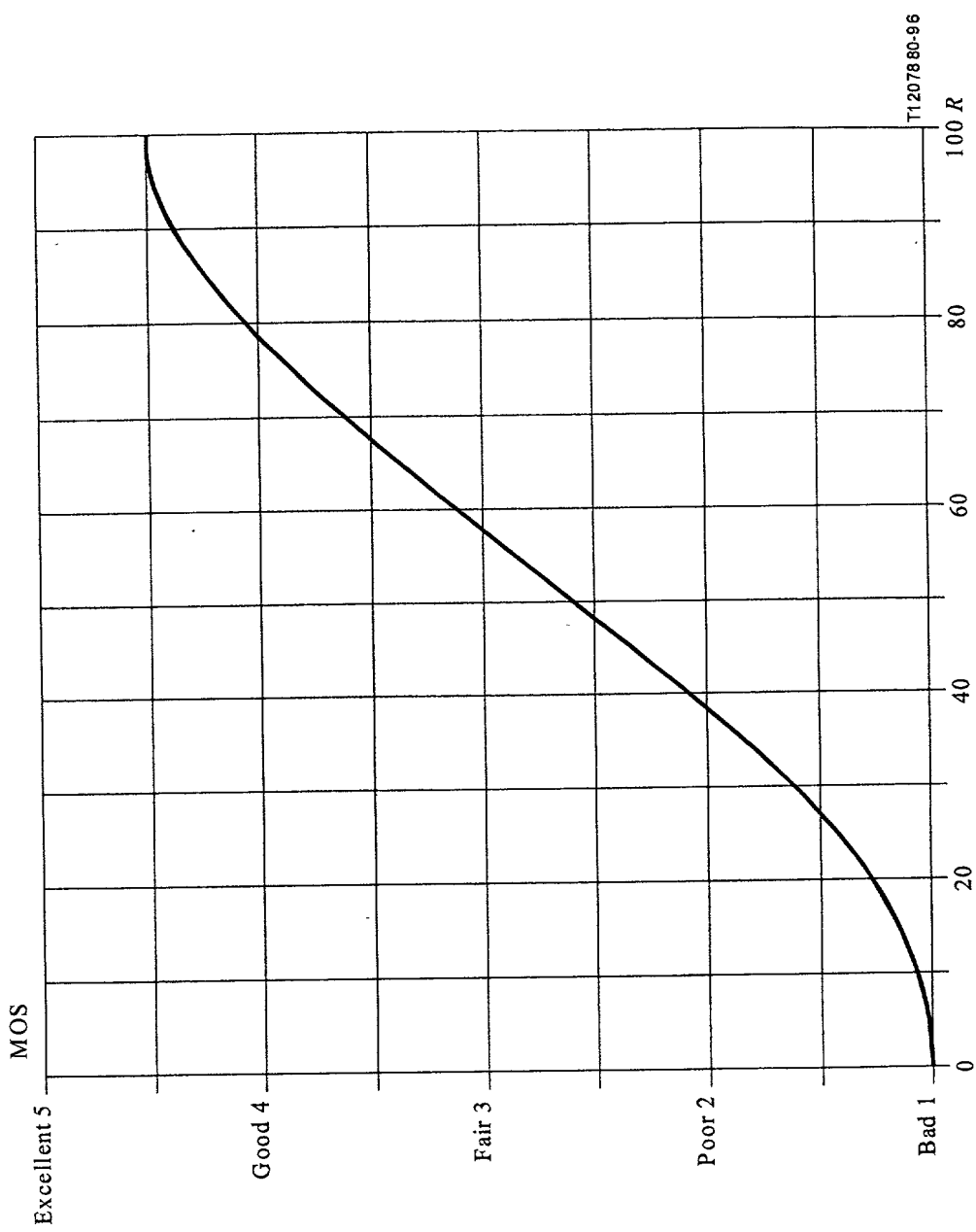


Figure B.2/G.107 – MOS as function of rating factor *R*

Fig. 5

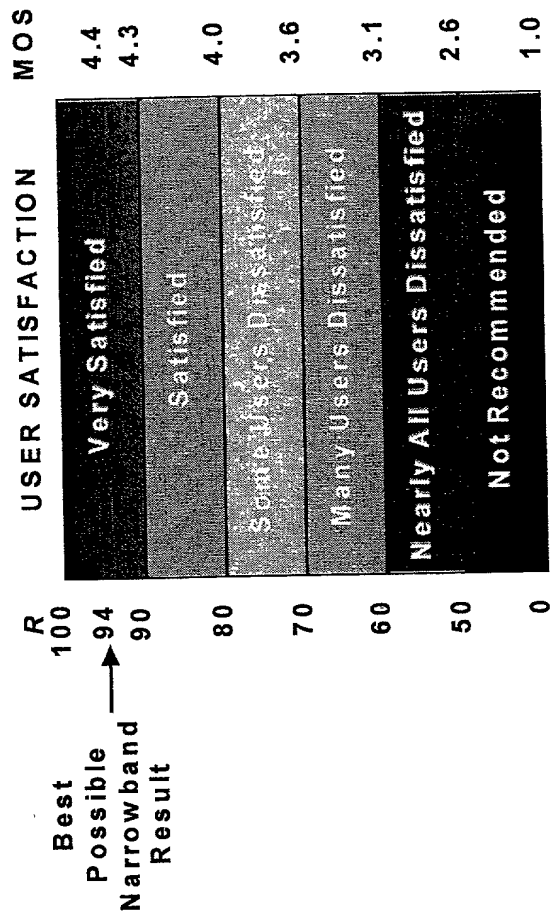


Fig. 6

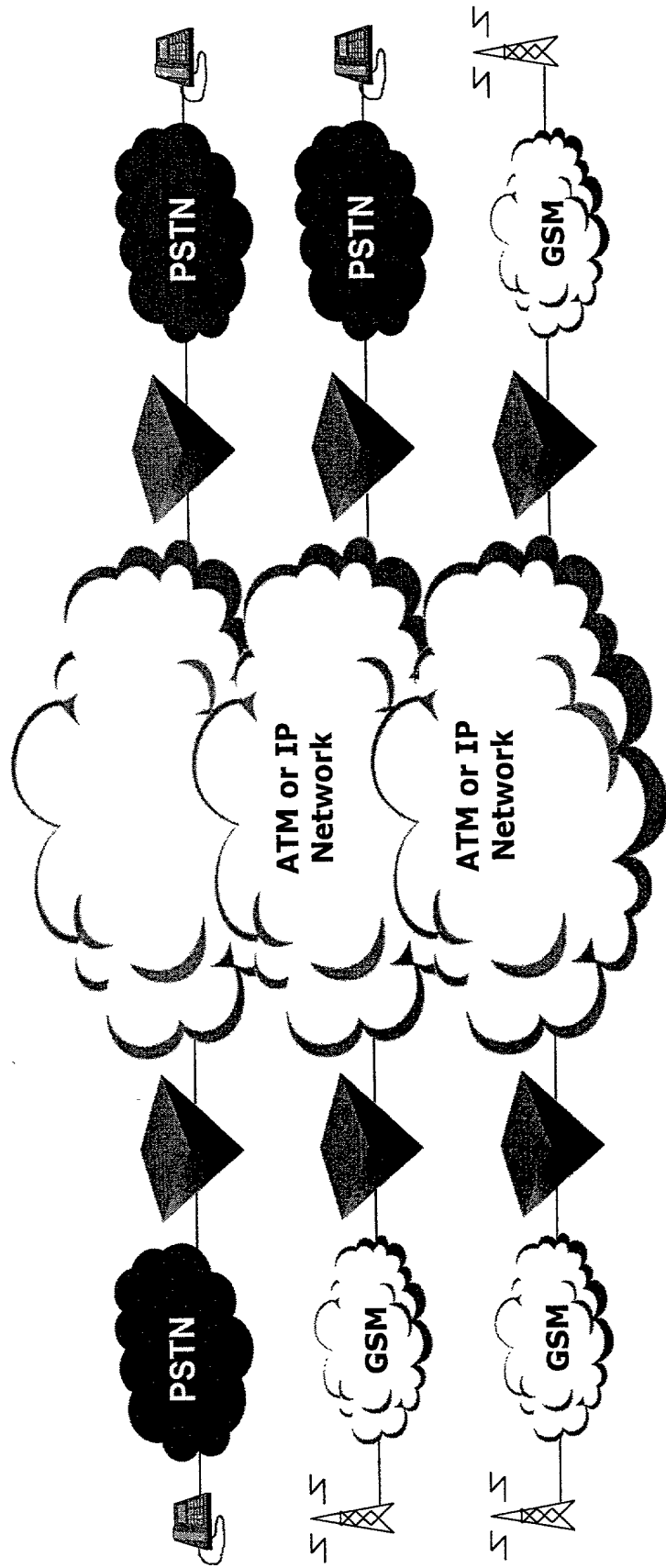
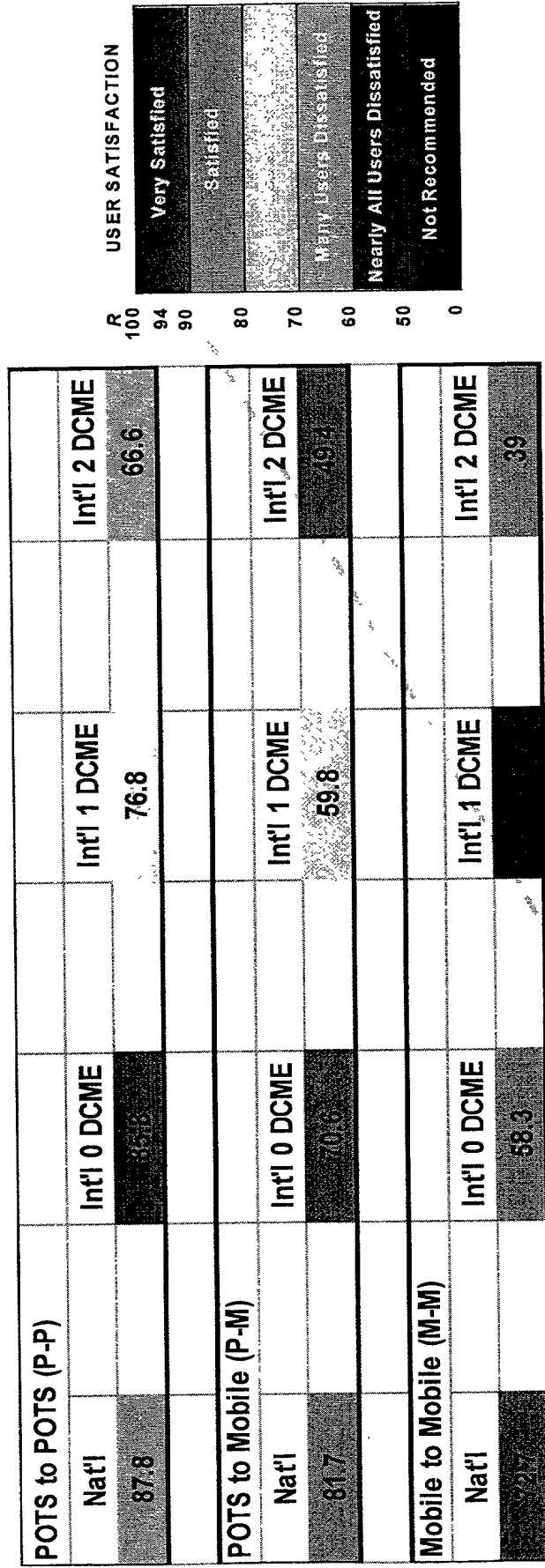


Fig. 7



Limit of acceptability - a hard threshold

Mobile is GSM EFR.

POTS is modelled for an analogue set.

Nat'l = 8000km, Int'l = 27500km.

Fig. 8

What reference calls will be the most demanding quality measure?

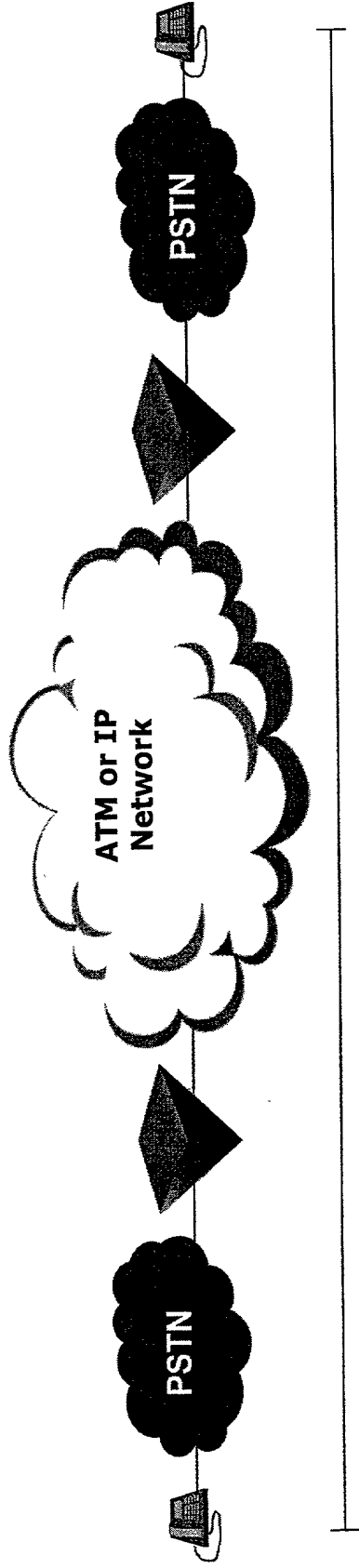


Fig. 9

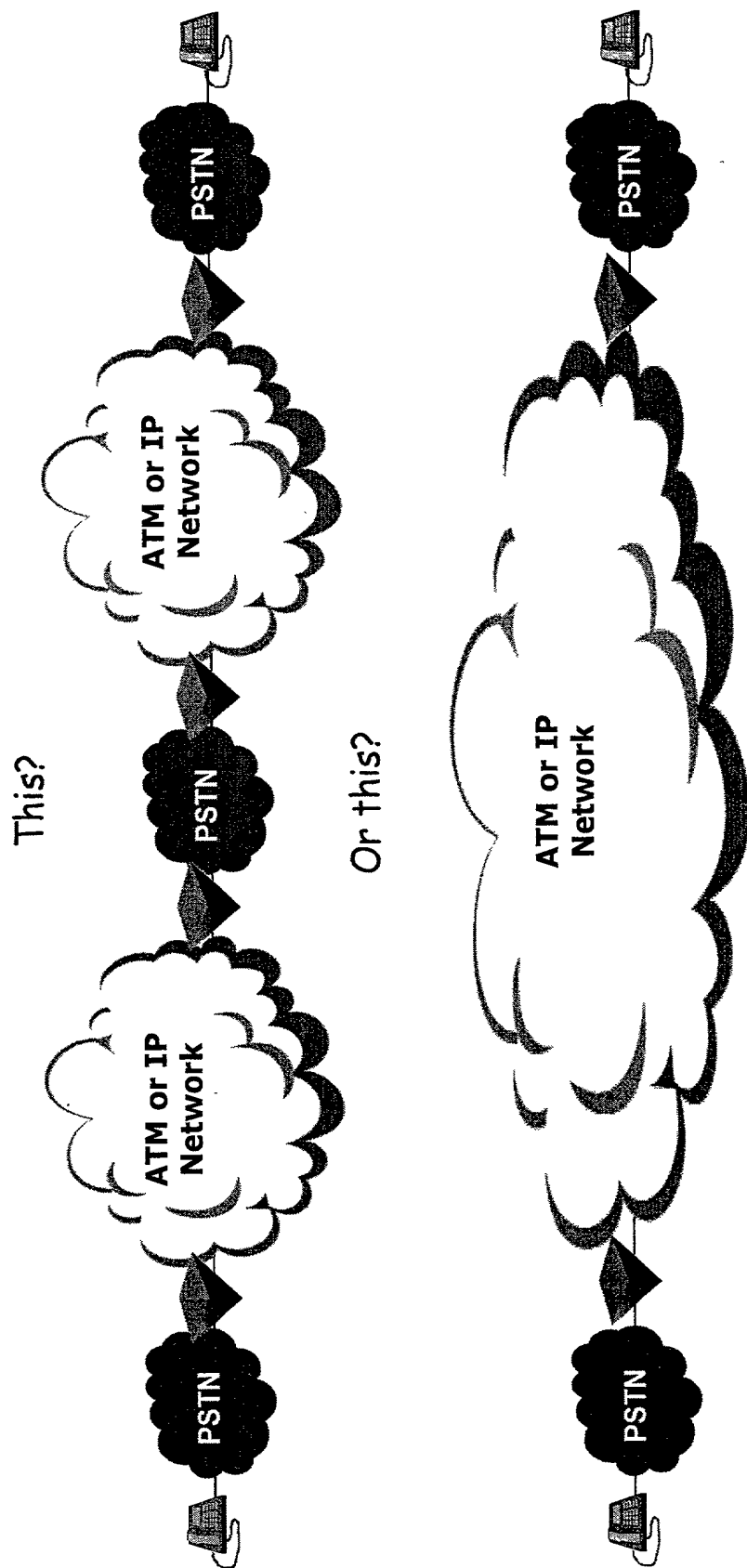
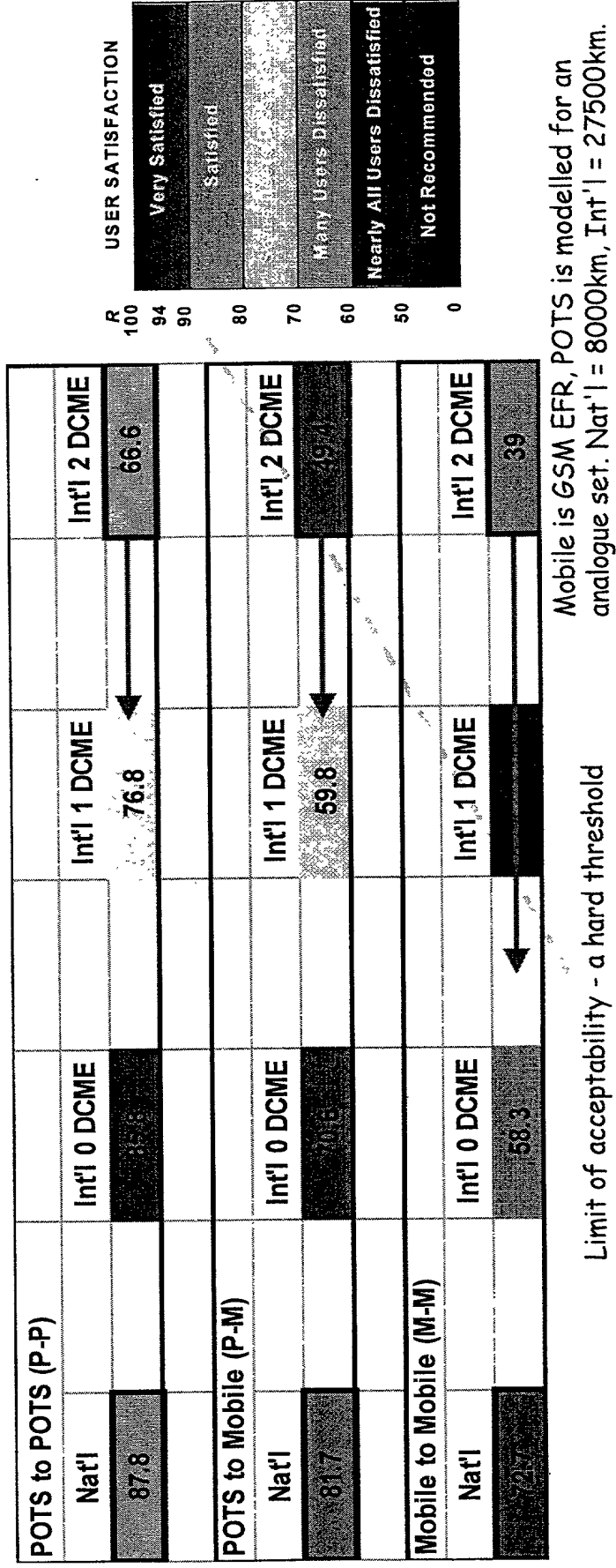


Fig. 10



(*5R = 0.2 MOS over most of the linear range considered in the statistical noise by many practitioners.)

Fig. 11

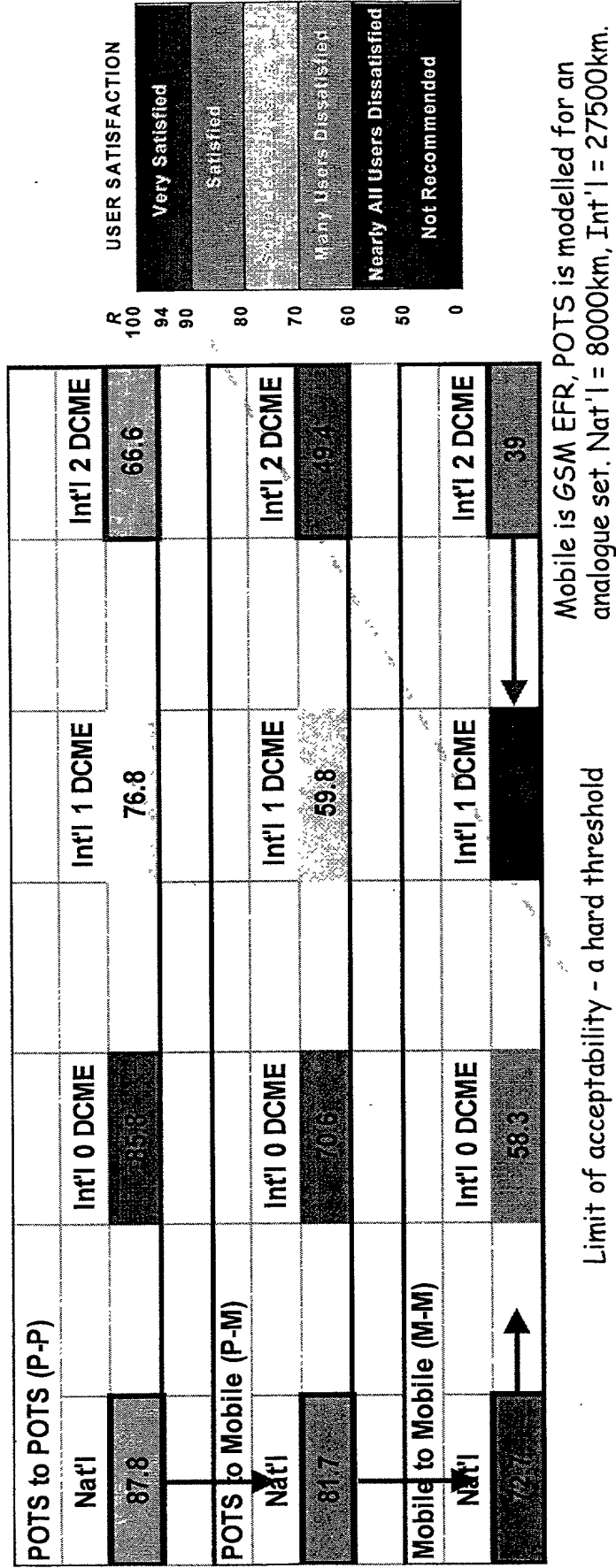


Fig. 12

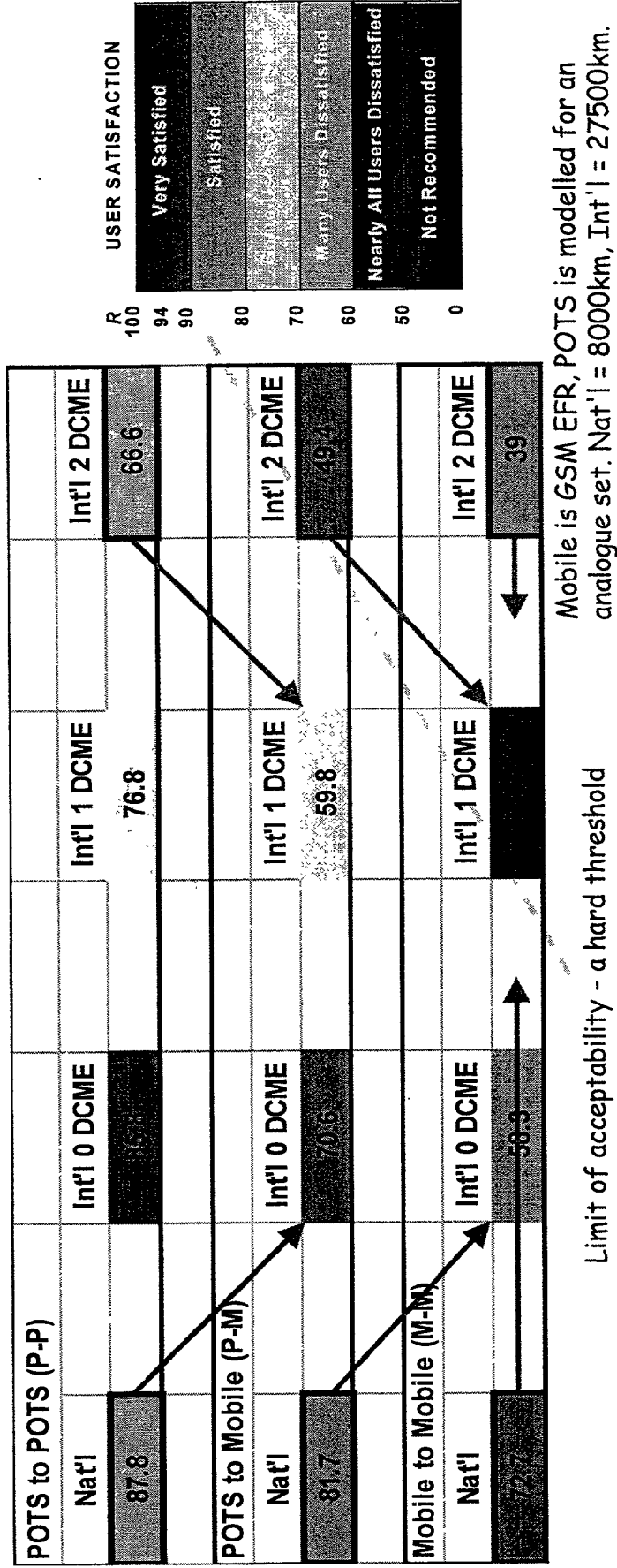


Fig. 13

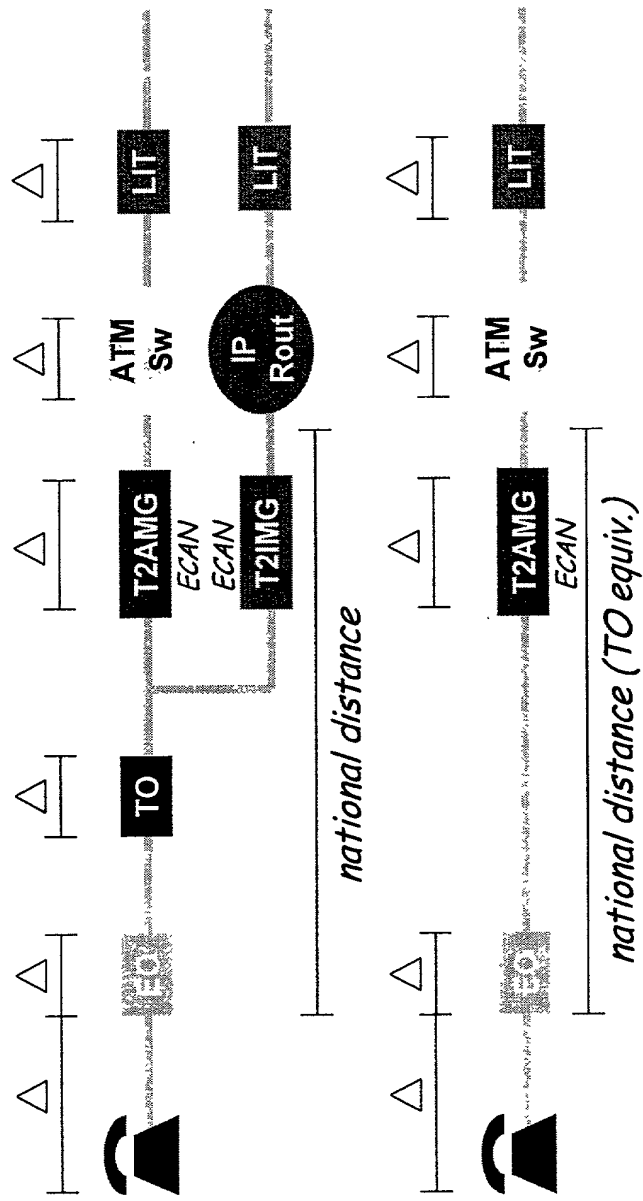


Fig. 14

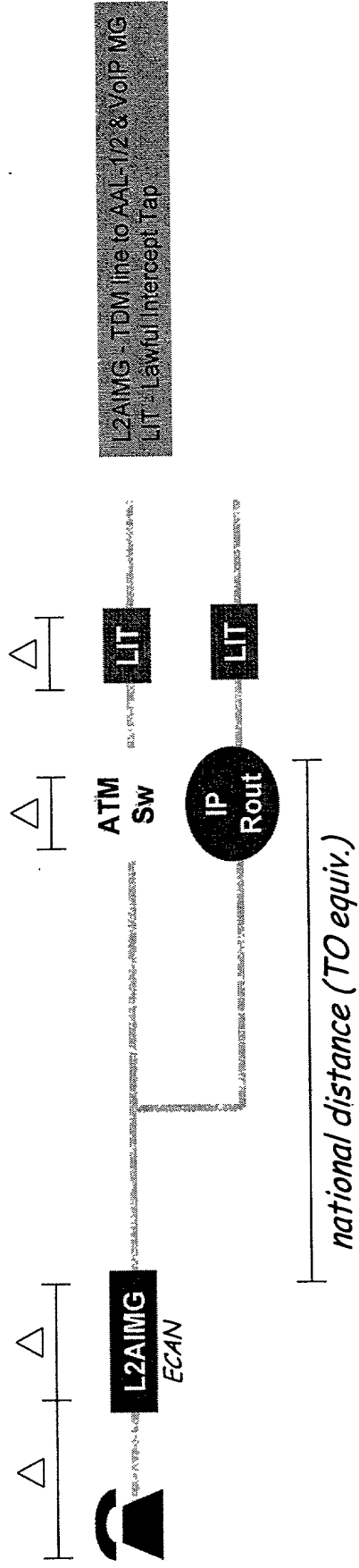


Fig. 15

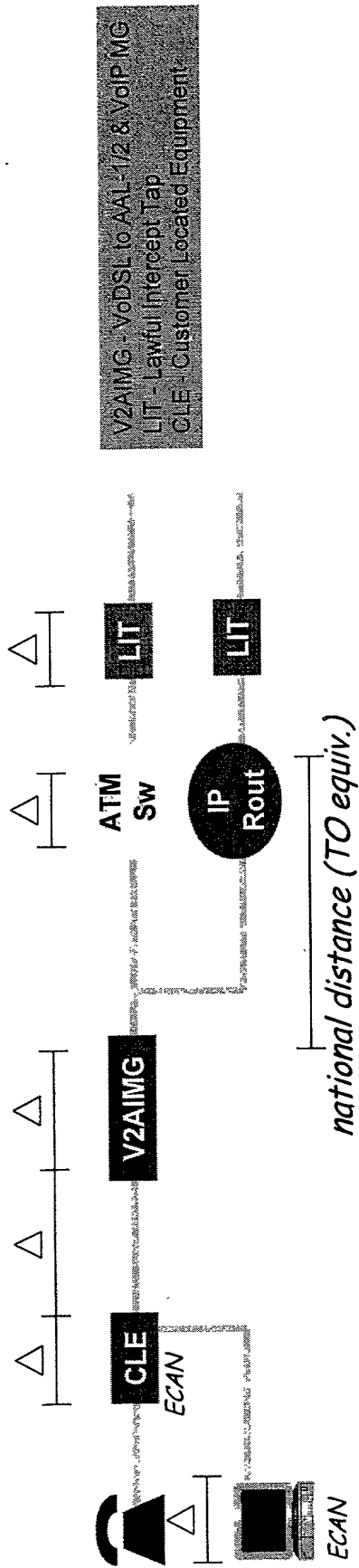


Fig. 16

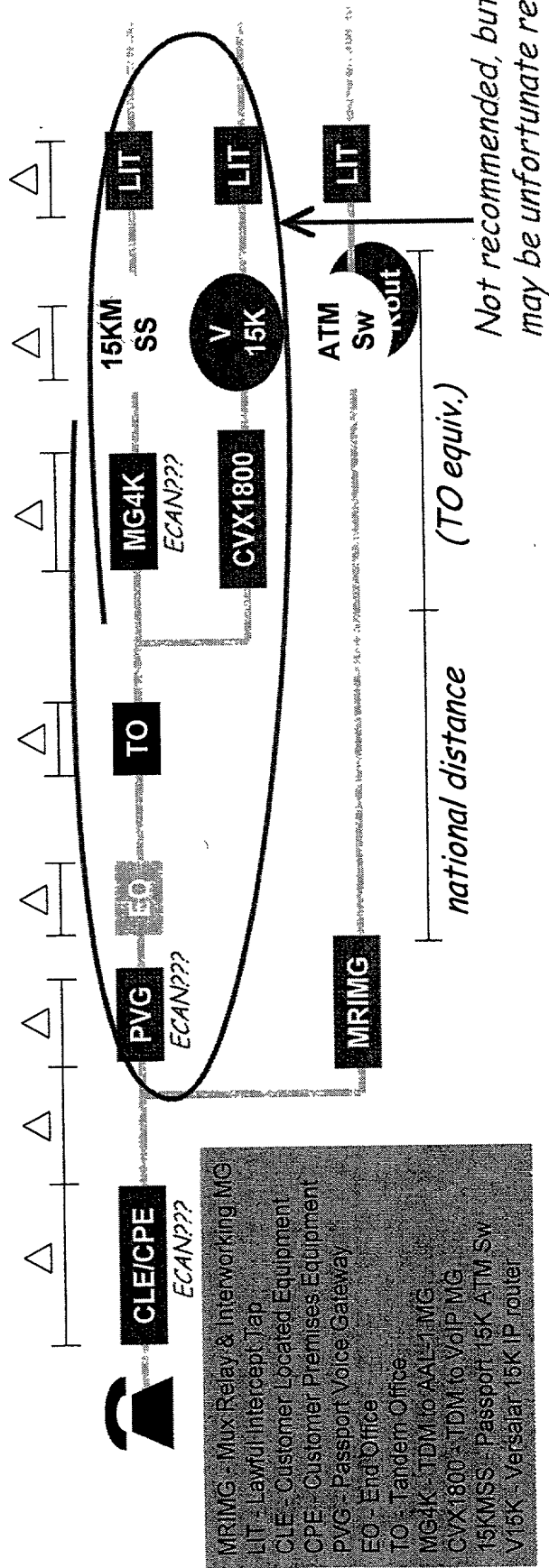
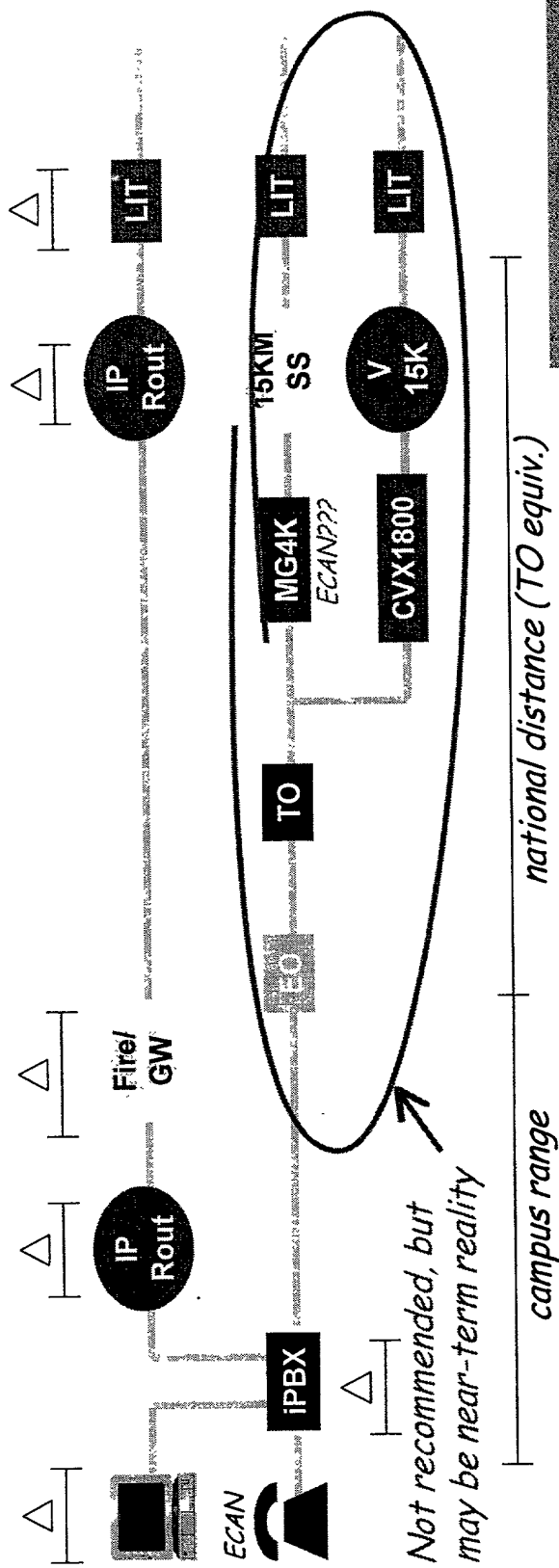


Fig. 17



MRIMG - Mux Relay & Interworking MG
 LIT - Lawful Intercept Tap
 CLE - Customer Located Equipment
 CPE - Customer Premises Equipment
 PVG - Passport Voice Gateway
 EO - End Office
 TO - Tandem Office
 MG4K - TDM to AAL-1 MG
 CVX1800 - TDM to VoIP MG
 15KMISS - Passport 15K ATM Sw
 V15K - Versalar 15K IP router

Fig. 18

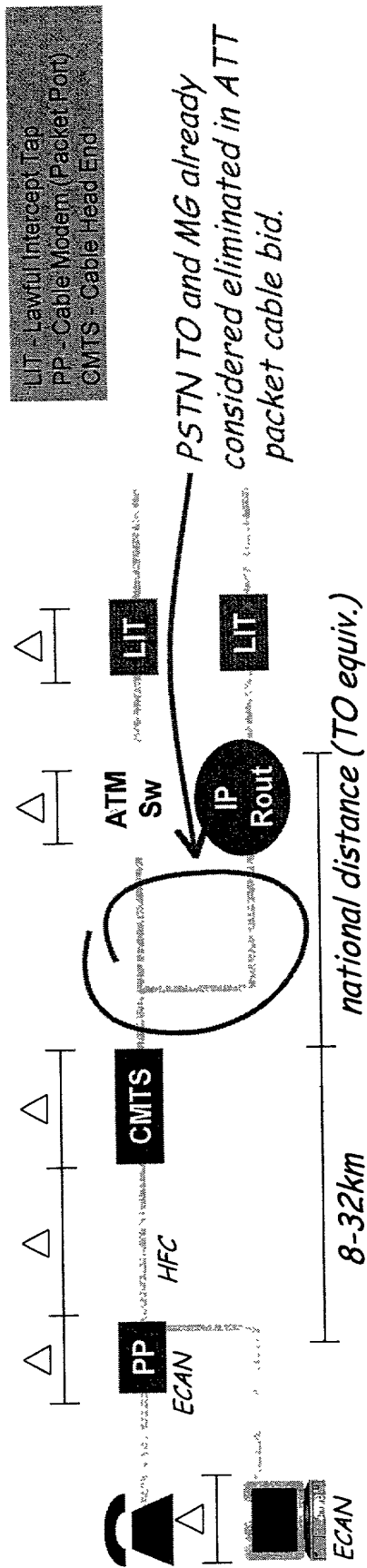


Fig. 19

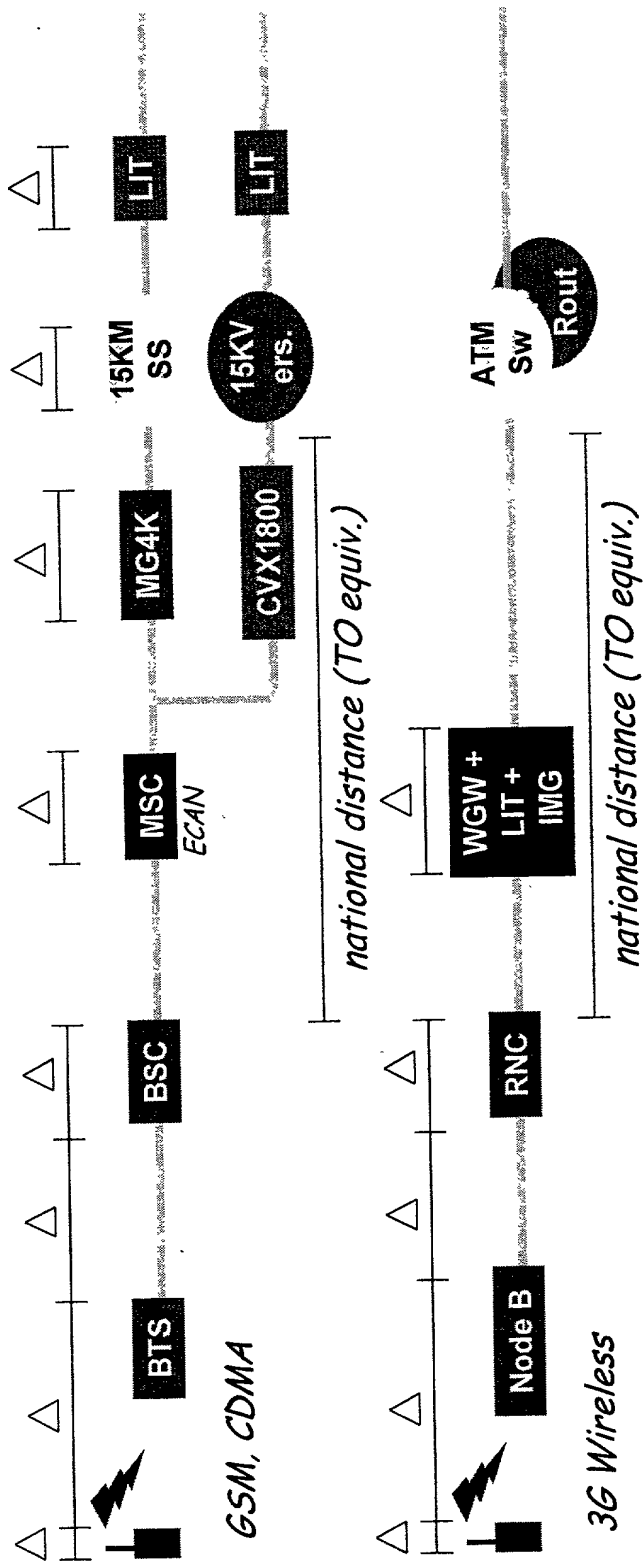


Fig. 20

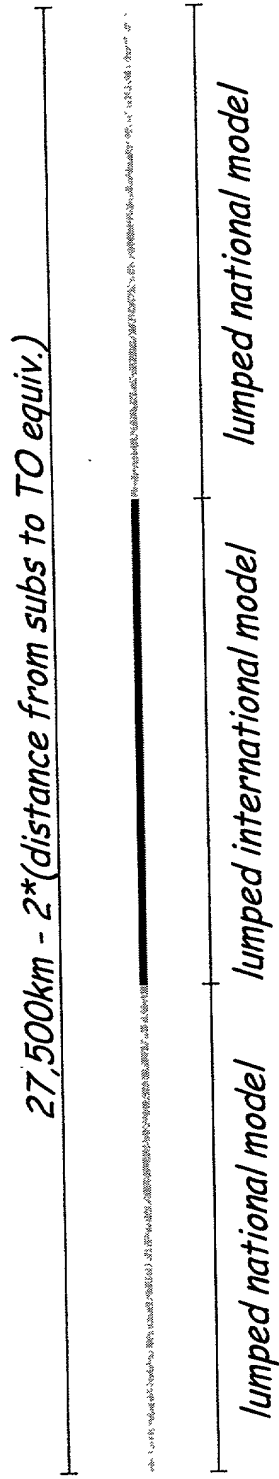
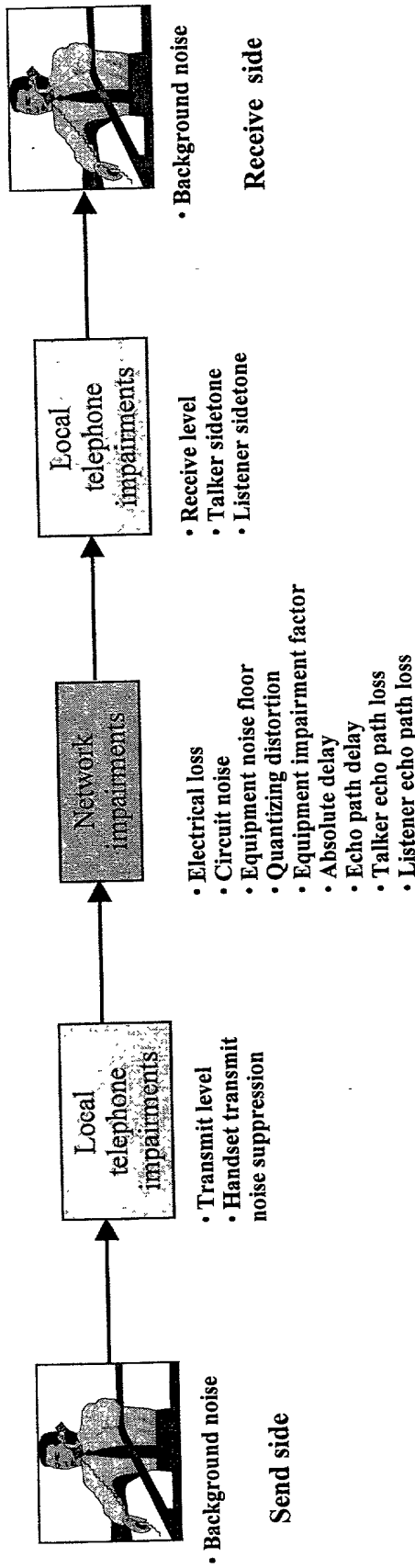


Fig. 21



The E-model calculates a Transmission Rating Factor R , given by

$$R = R_0 - I_s - I_d - I_e + A$$

Fig. 22

E-Model Parameter Default Values

Parameter	Units	Value
SLR (Send Loudness Rating)	dB	8
RLR (Receive Loudness Rating)	dB	2
STM _R (Sidetone Masking Rating)	dB	15
LSTR (Listener Sidetone Rating)	dB	18
OLR (Overall Loudness Rating)	dB	10
TELR (Talker Echo Loudness Rating)	dB	65
WEPL (Weighted Echo Path Loss)	dB	110
T (Mean Intrinsic One-Way Delay)	msec	0
T _a (Absolute Delay)	msec	0
T _r (Round-Trip Delay)	msec	0
QDU (Quantization Distortion Units)	-	1
I _e (Equipment Impairment Factor)	-	0
A (Expectation Factor)	-	0
D _s (Handset Shape Factor – Send Side)	-	3
D _r (Handset Shape Factor – Receive Side)	-	3
P _s (Room Noise at the Send side)	dB(A)	35
P _r (Room Noise at the Receive side)	dB(A)	35
N _c (Circuit Noise referred to 0 dB _r -point)	dBm0p	-70
N _{for} (Noise Floor at the Receive Side)	dBmp	-64

Fig. 23

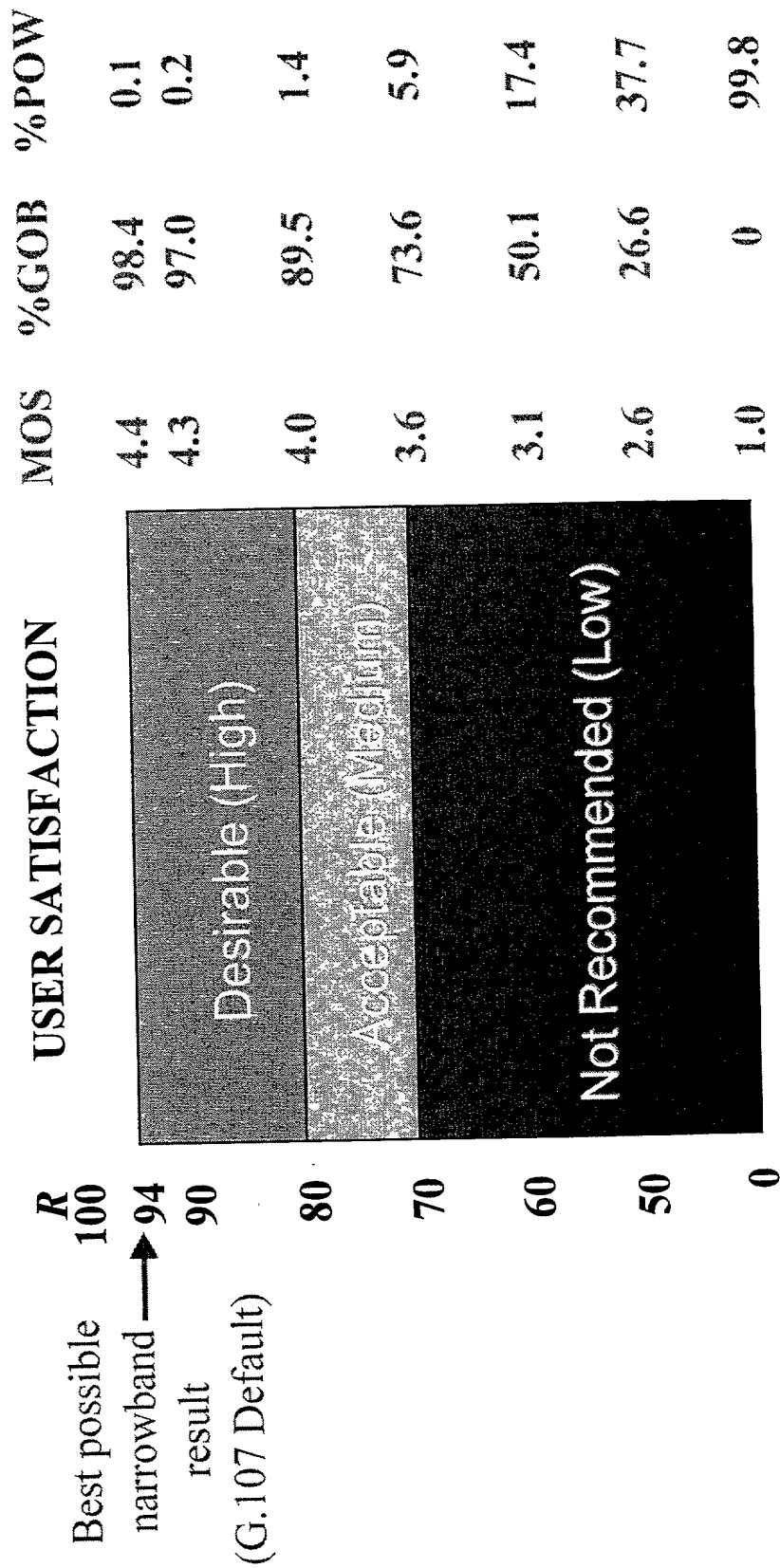


Fig. 24

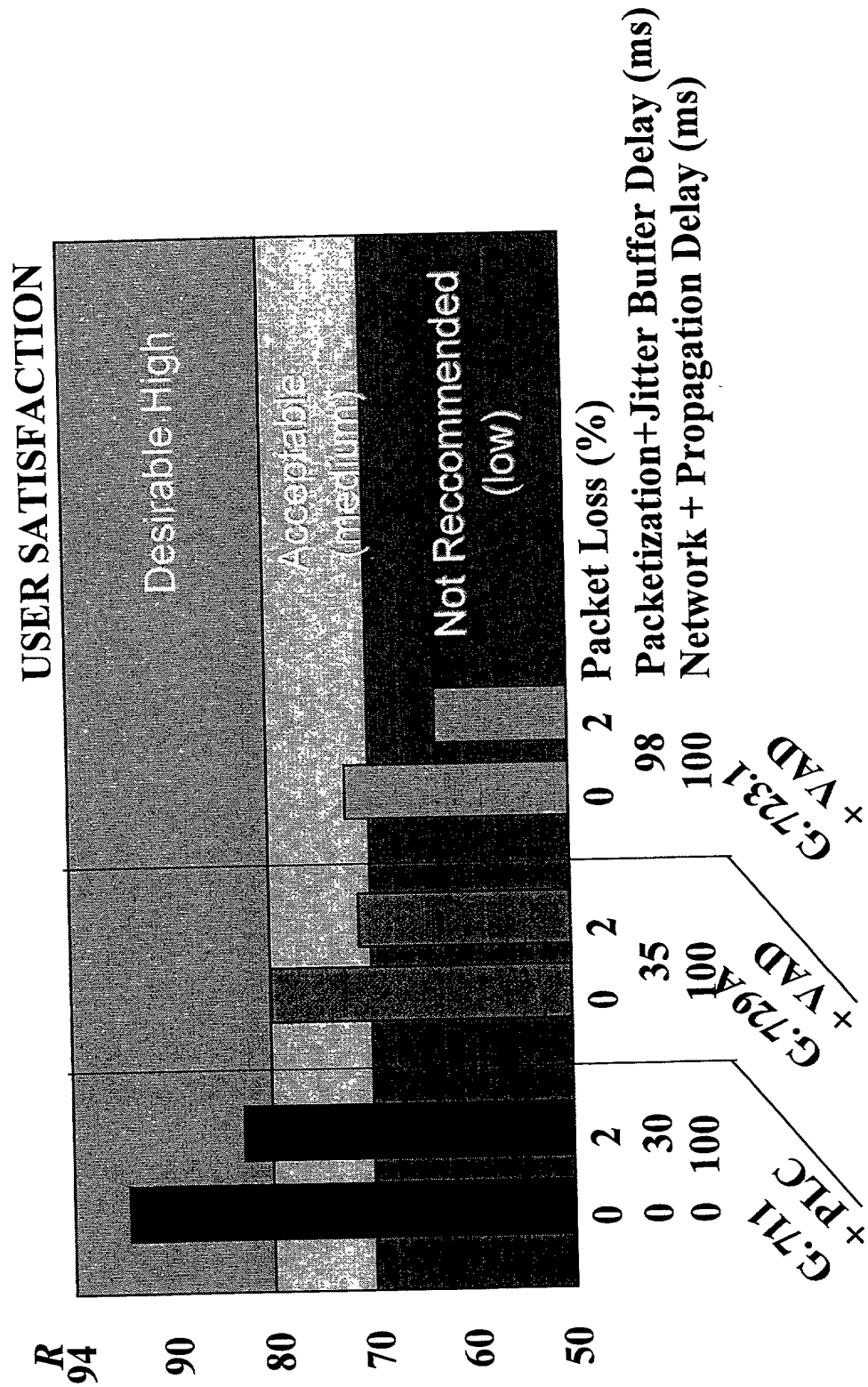


Fig. 25

Table for E-Model Calculations								
	G.711 [Ref 10] [Notes 2, 3]	G.711 [Notes 1, 2, 3]	G.711 [Notes 1, 2, 3, 4]	G.729A [Notes 1, 3]	G.729A [Ref 10] [Note 5]	G.729A [Notes 1, 3]	G.729A [Notes 1, 3]	G.726 32kb/s note [5]
Frame Size (ms)	125	125	125	10	10	10	10	125
Packet Payload (ms)	10	20	30	10	20	30	40	20
Packet Loss (%)								
0	0	0	0	11	11	11	11	7
1	5	8	10	13	15	17	19	N/A
2	7	13	16	16	19	21	24	N/A
3	10	19	22	19	23	25	28	N/A
4	12.5*	22	26	22	26	29	32	N/A
5	15	25	30	25	29*	32	35	N/A

Notes:

- 1) In the absence of any supporting documentation, these are arbitrary values
- 2) All G.711 vocoders are assumed to have PLC (Packet Loss Concealment) algorithms
- 3) Impairment factors apply for random packet loss conditions
- 4) This is the current capability of the i2004 (in the absence of any download instructions to achieve smaller frame size)
- 5) There is no PLC algorithm for G.726, therefore its deployment might be limited in lossy network
- 6) Interpolated values

Fig. 26

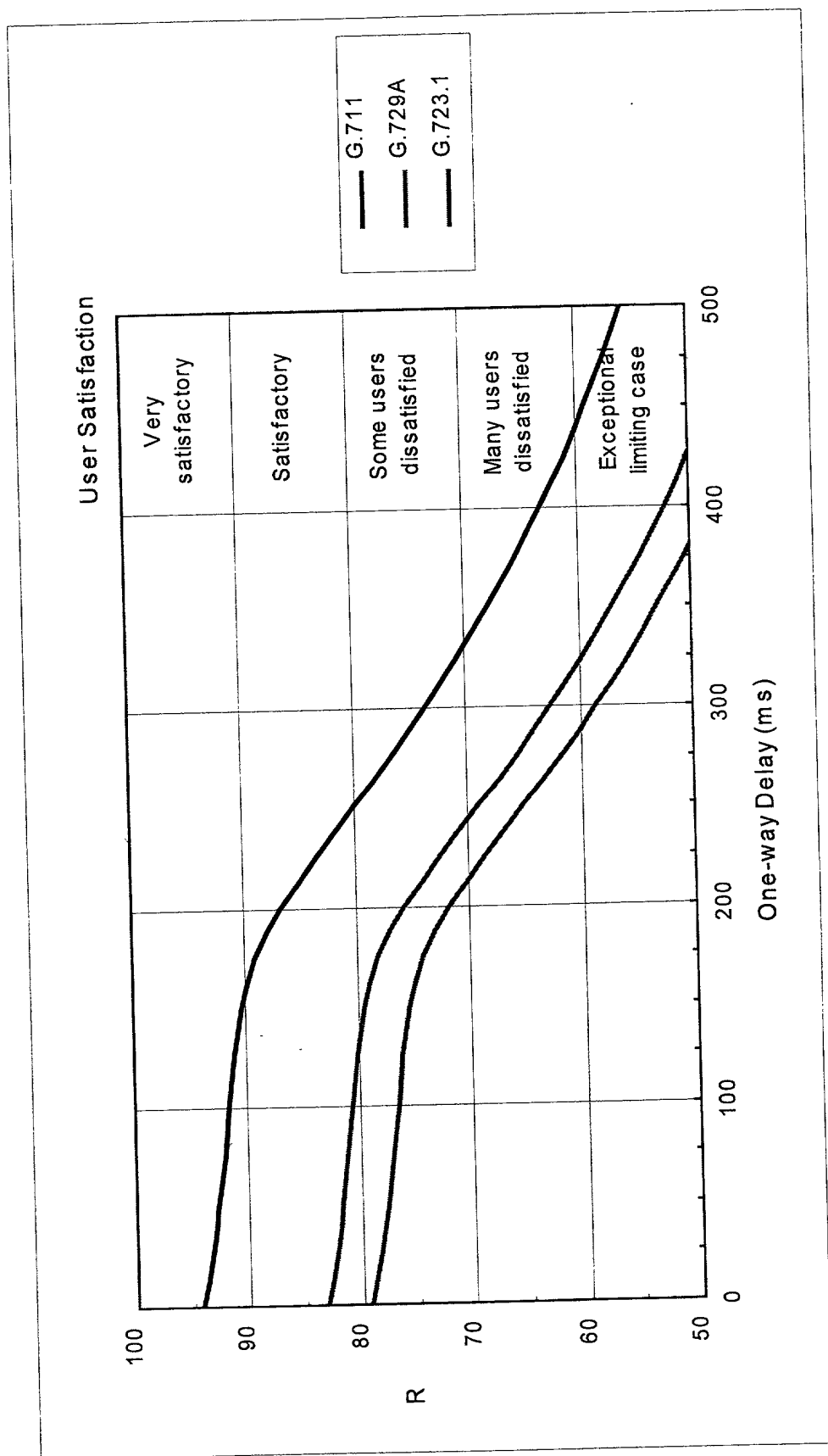


Fig. 27

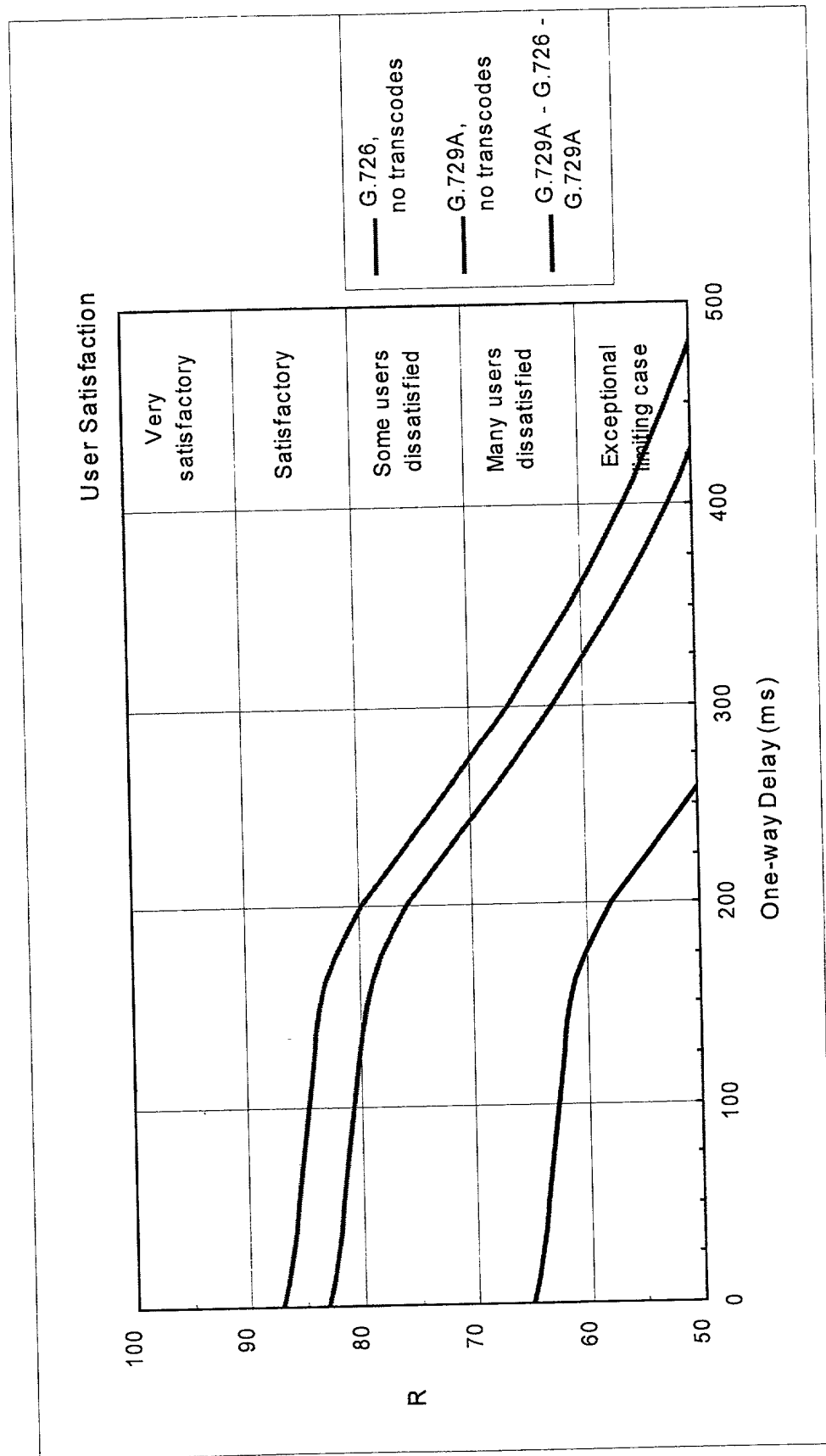


Fig. 28

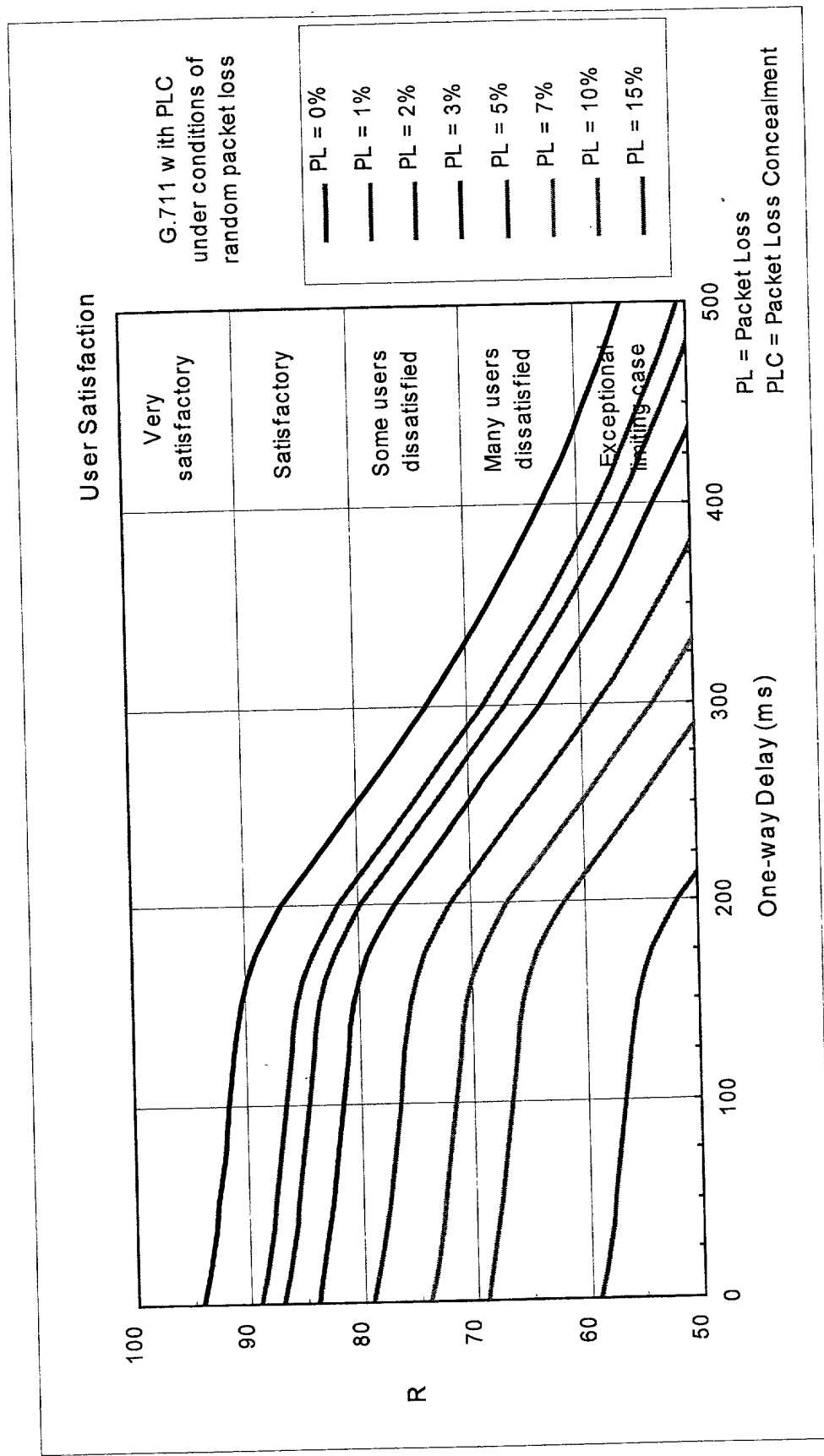


Fig. 29

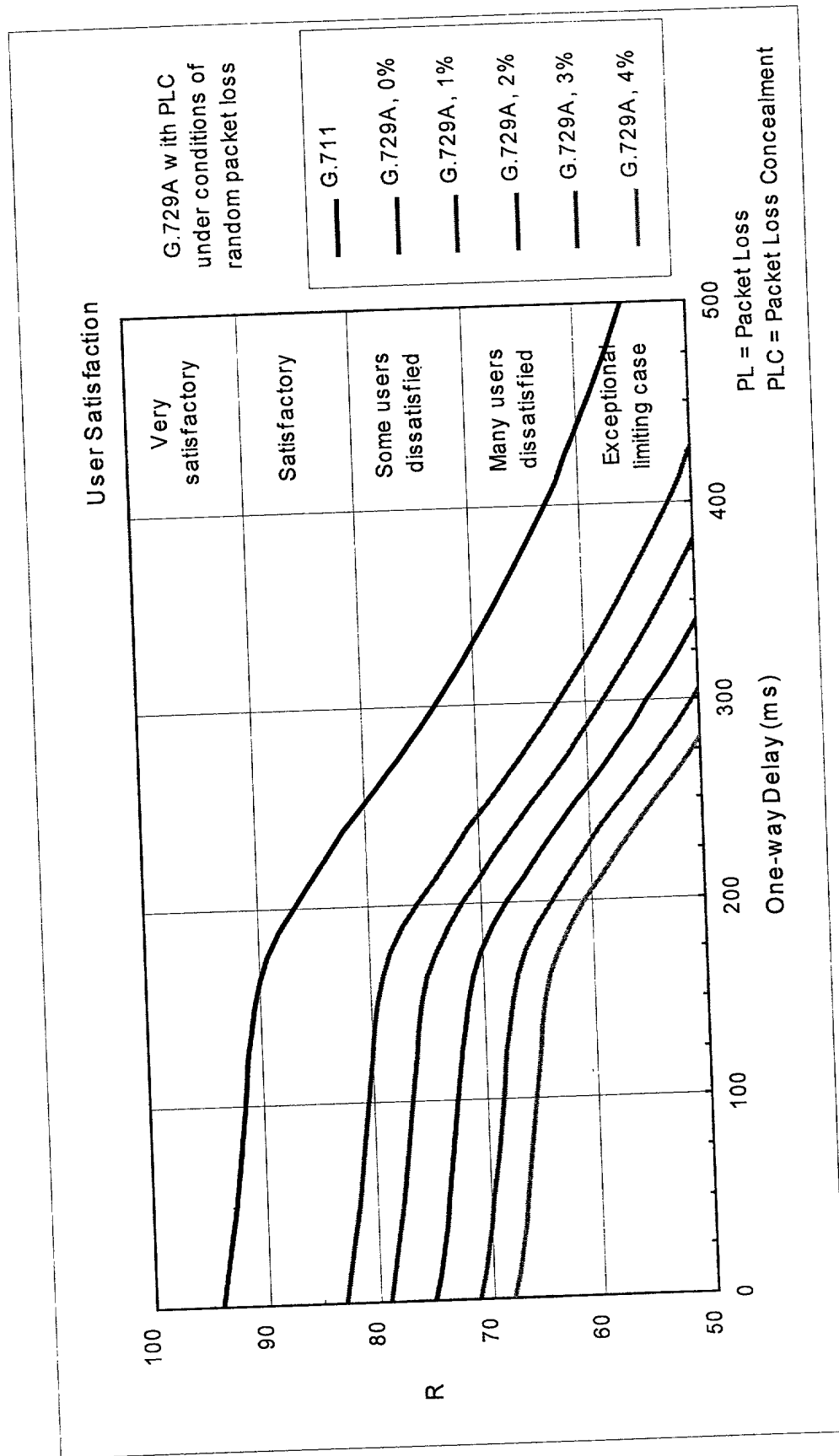


Fig. 30

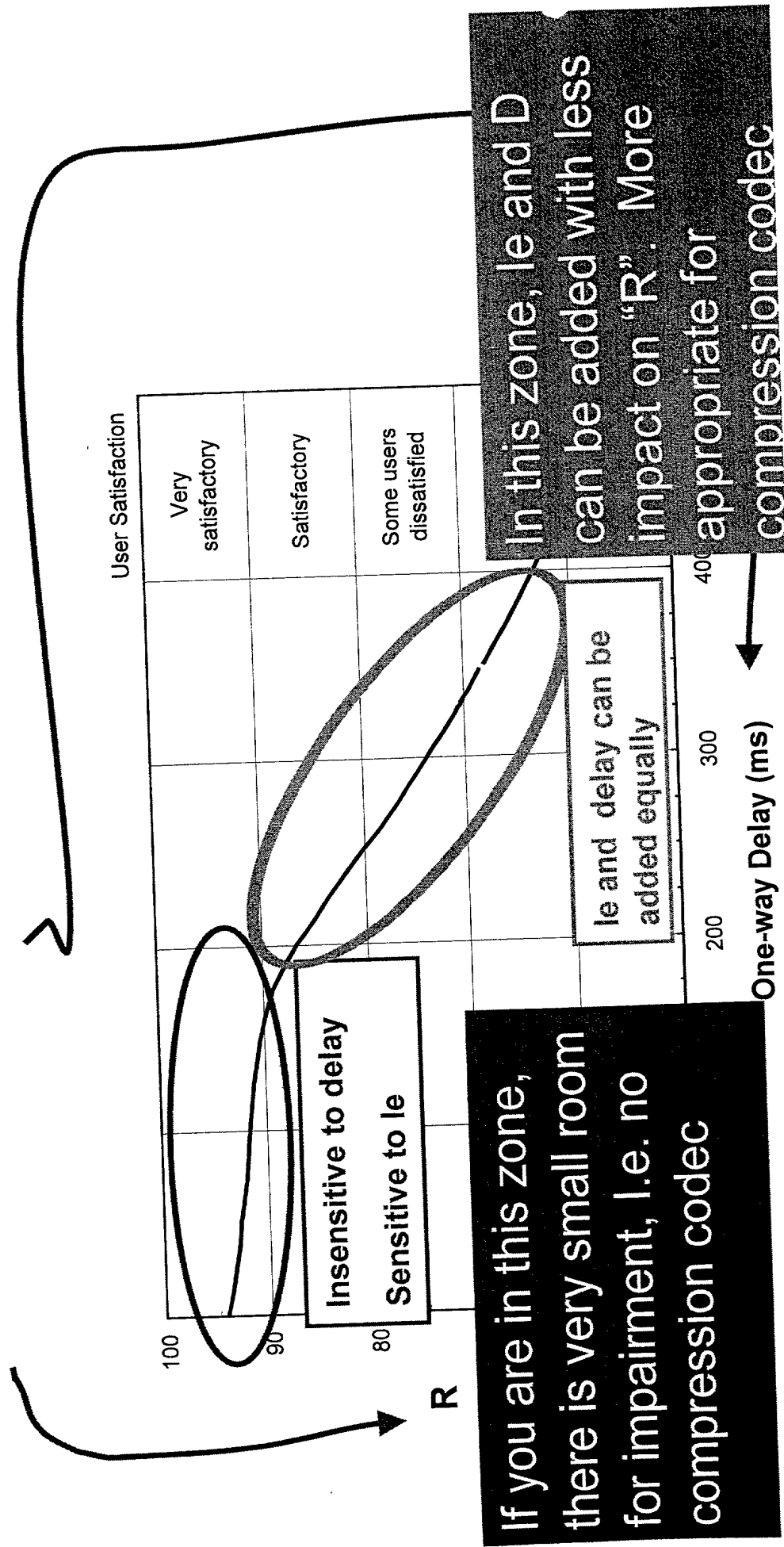


Fig. 31

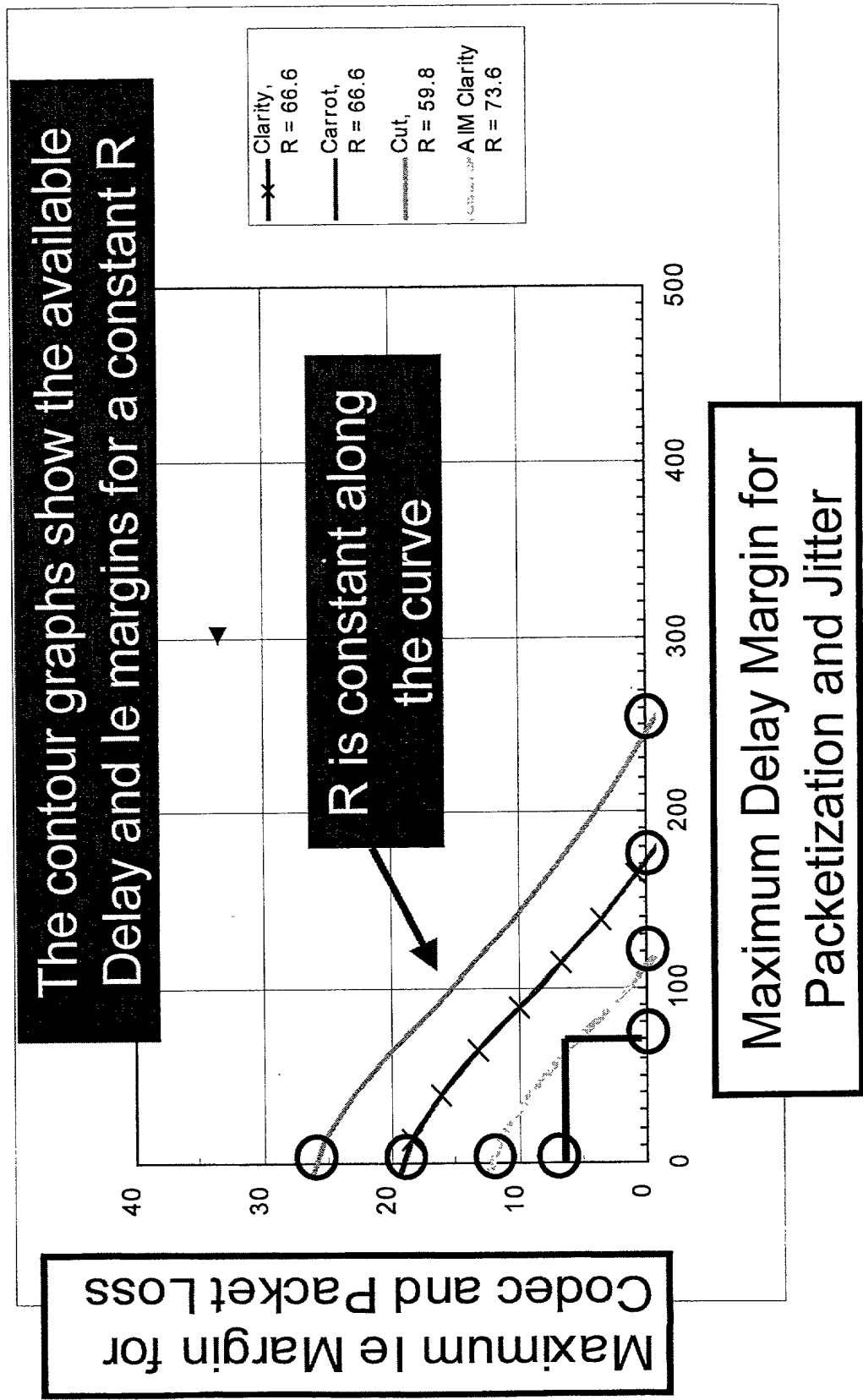


Fig. 32

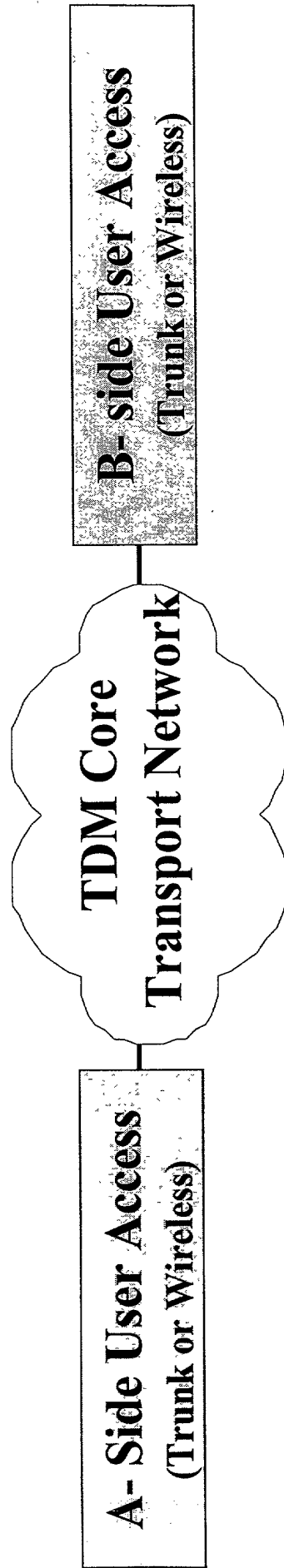
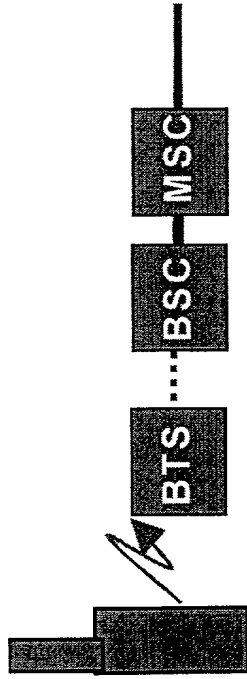


Fig. 33



Title	Abbreviation (Default)	E-Model Input
Electric Circuit Noise (at 0 dBr)	Nc (-70 dBmP)	
Room Noise	Po (35 dBA)	35
Send Loudness Rating	SLR (8 dB)	11
Receive Loudness Rating	RLR (2 dB)	3
D-factor	D (3)	3
Noise Floor	Nfor (-64 dBm0)	-64
Sidetone Masking Rating	STM (15)	15
Equipment Impairment Factor	Ie (0)	0
Expectation (Advantage) Factor	A (0)	0
Mean Intrinsic One-Way Delay (upper)	Tu (0 ms)	0
Mean Intrinsic One-Way Delay (lower)	Tl (0 ms)	0
Mean Intrinsic One-Way Delay	Tul (0 ms)	0
Electrical Loss (upper)	Lu (dB)	0
Electrical Loss (lower)	Ll (dB)	0
Electrical Loss (upper = lower)	Lul (dB)	0
Quantizing Distortion Units (upper)	qduu (1) [Note 1]	0
Quantizing Distortion Units (lower)	qdul (1) [Note 1]	0
Echo Return Loss	ERL (dB)	17

Fig. 34



BTS: Base Station
 BSC: Base Station Controller
 MSC: Mobile Switching Center

PSTN Wireless Access Delay, loss and Impairment Summary		
	Uplink	Downlink
Mobile Switching Center (MSC) (ms)	1	2
Base Station Controller (BSC) (ms)	2.5	40
Base Station (BTS) (ms)	15.8	40.8
Mobile Set (MS) (ms)	72.1	14.3
PSTN Wireless Access Delay (ms)	91.40	97.10
Impairment Factor (Ie)	5	5

Fig. 35

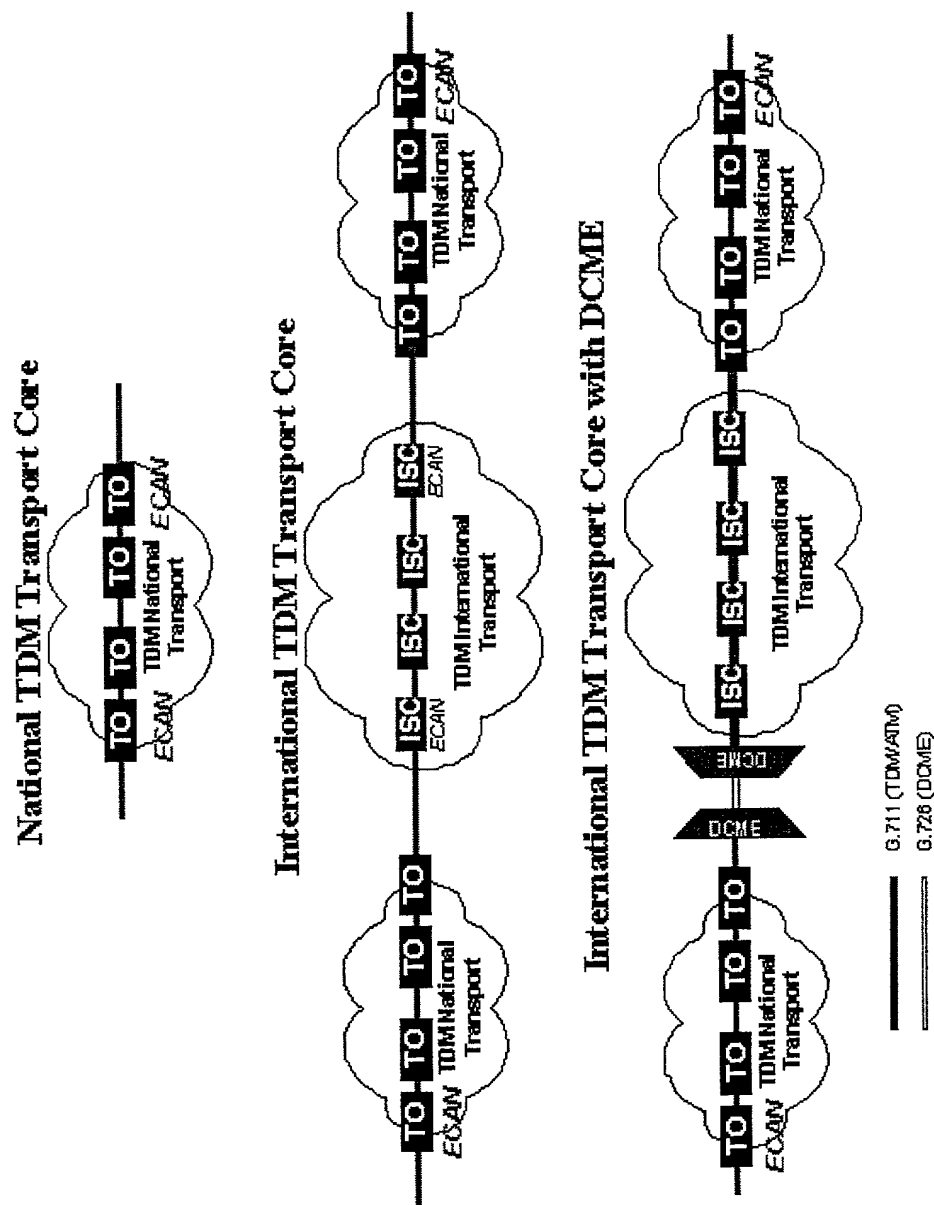


Fig. 36

TDM Core Transport	National (8000km)	International (connection Length 27500 km)		
		0 DCME	1 DCME	2 DCME 3 DCME
National Transmission Time	43	43	43	43
T2DCME (G.711/G.726 Conversion+DSI) (ms)	-	0	26	52
DCME2T (G.726/G.711 Conversion) (ms)	-	0	2	4
International Transmission Time (ms)	-	72	72	72
National Transmission Time	-	43	43	43
Total one-way delay (ms)	43	158	186	214
Impairment Factor (Ie)	0	0	7	14
				21

Fig. 37

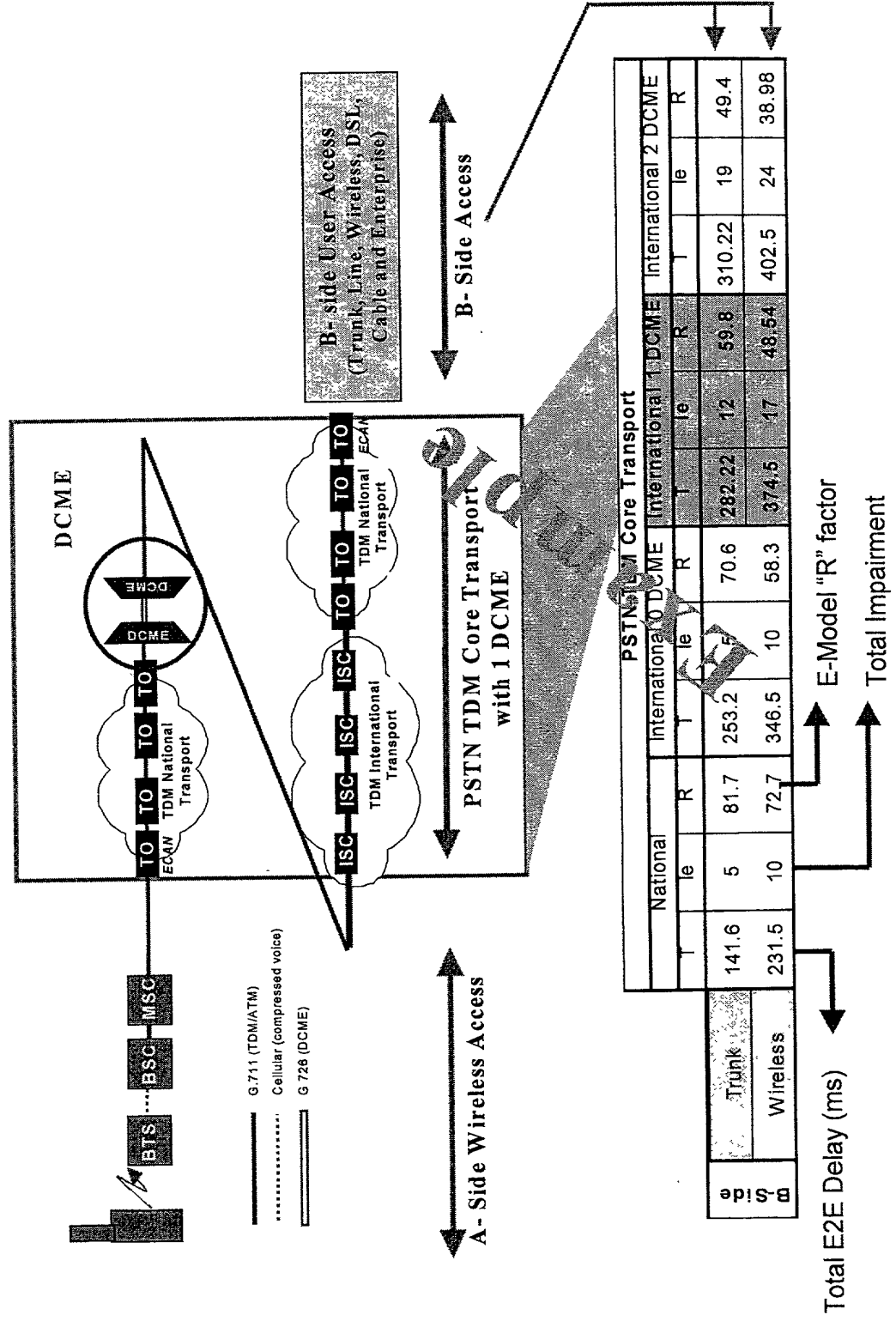
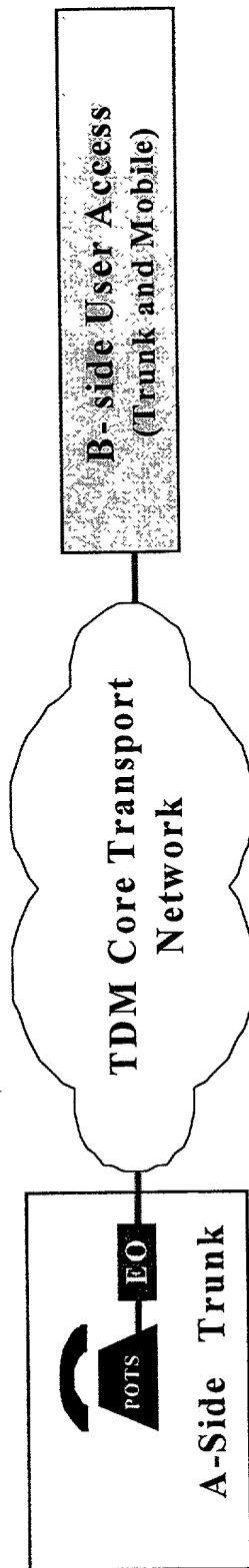


Fig. 38



Described in section 5.1

Described in section 5.2 and 5.3

Trunk Access to	National			International 0 DCME			International 1 DCME			International 2 DCME		
	T	le	R	T	le	R	T	le	R	T	le	R
Trunk	46	0	87.8	161.22	0	85.8	190.22	7	76.8	218.22	14	66.6
Wireless	139.24	5	81.7	253.22	5	70.6	282.22	12	59.8	310.22	19	49.4

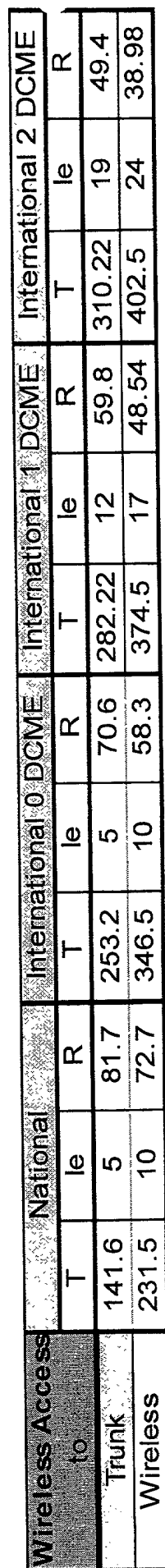


Fig. 40

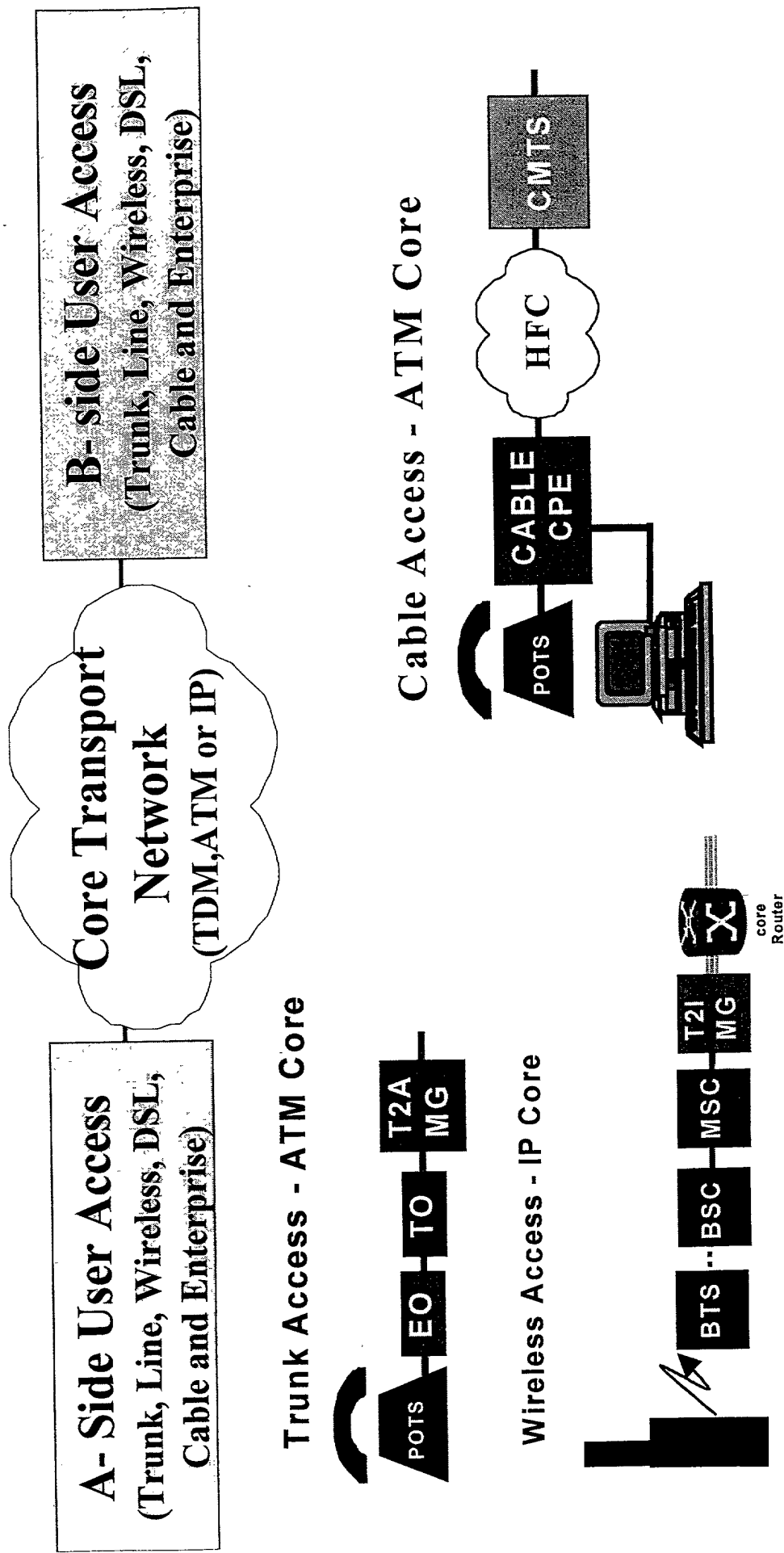


Fig. 41

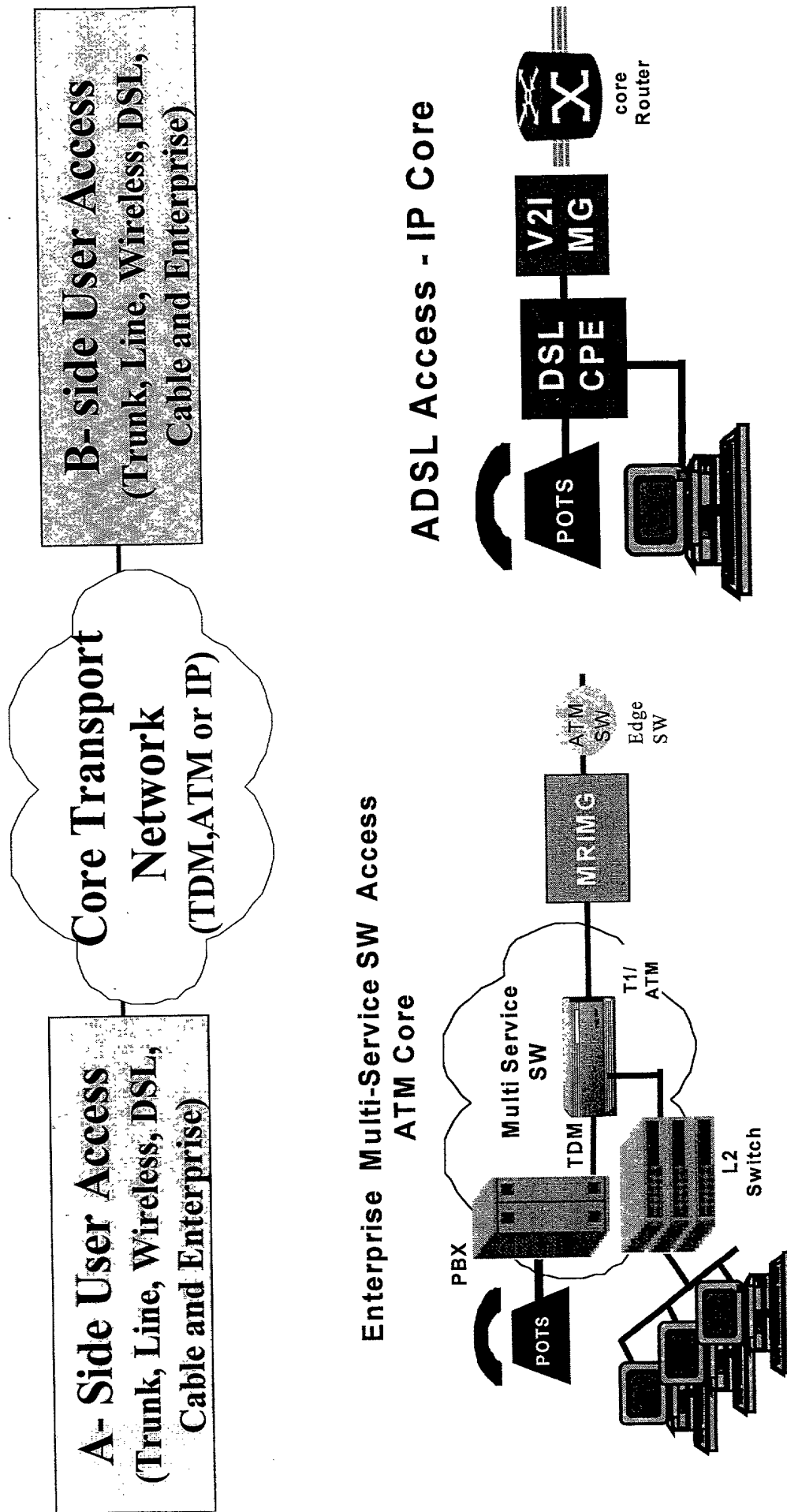


Fig. 42

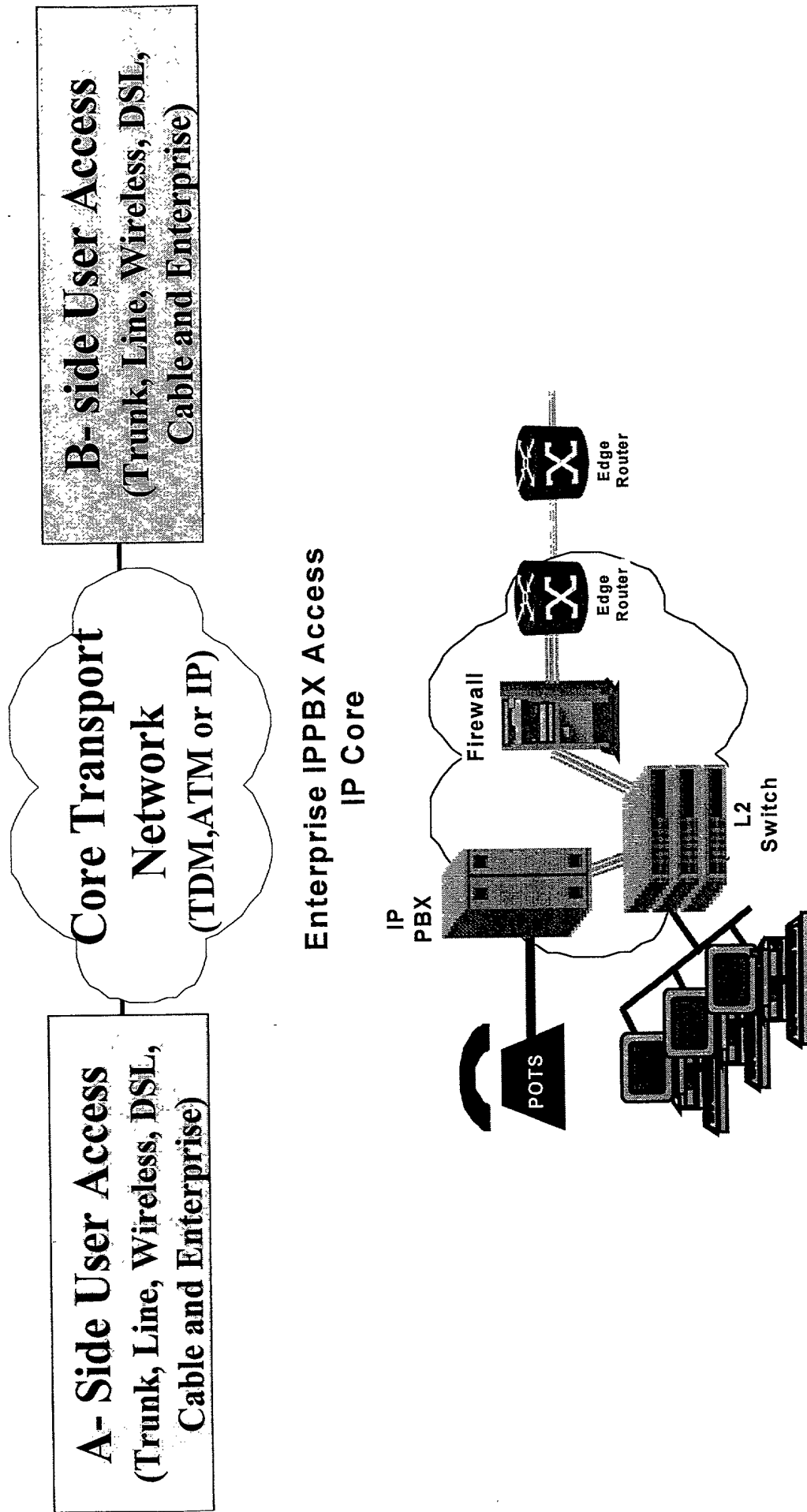


Fig. 43

Which impairments are being considered in the models?

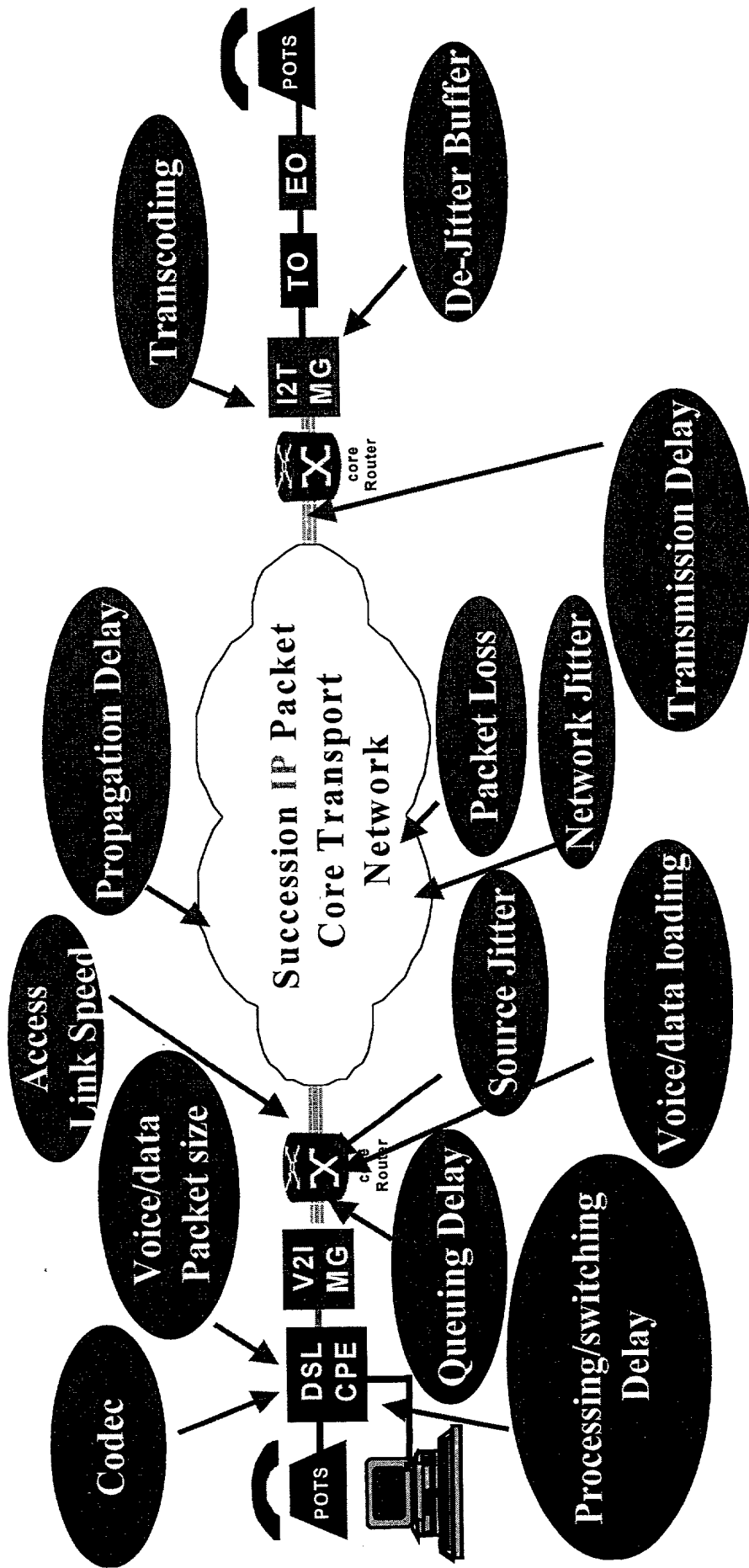
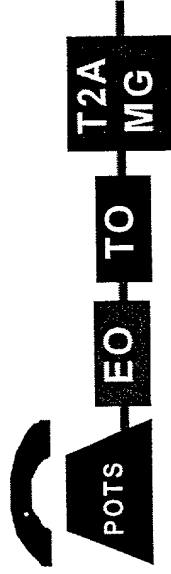


Fig. 44

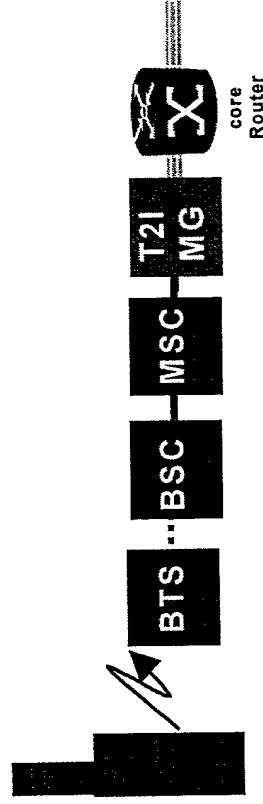
Trunk Access - ATM Core



Trunk Access to ATM Core (before 4 parameters budget assignment) Delay, loss and Impairment Summary	
Set delay (Side A) (ms)	0
End Office Delay (Side A) (ms)	1.5
Tandem Office Delay (Side A) (ms)	0.75
T2AMG delay (Side A) (ms)	0.5
Trunk Access delay (ms)	2.75
Impairment Factor (Ie)	0

Fig. 45

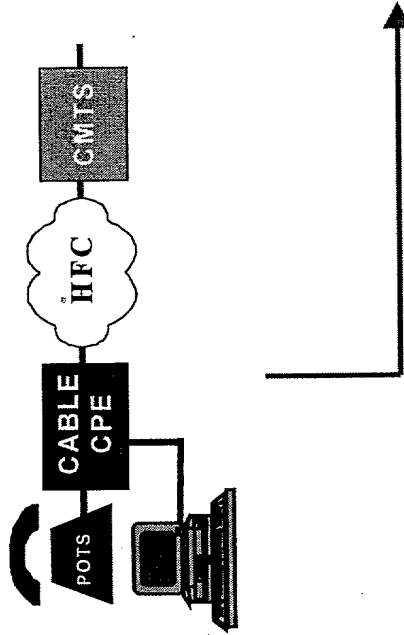
Wireless Access - IP Core



Succession Wireless to ATM Core - Delay, loss and Impairment Summary (before 4 parameters budget assignment)		
	Uplink	Downlink
Mobile Switching Center (MSC) (ms)	1	2
Base Station Controller (BSC) (ms)	2.5	40
Base Station (BTS) (ms)	15.8	40.8
Mobile Set (MS) (ms)	72.1	14.3
T2AMG delay (Side A) (ms)	0.5	0.5
Wireless Access delay (ms)	91.40	97.10
Impairment Factor (Ie)	5	5

Fig. 46

Cable Access - ATM Core



Cable CPE	Cable CPE Upstream	Cable CPE Downstream	Note
Link Speed	510 Kbps	3000 Kbps	note [1]
Voice packet size (byte)	160	160	note [2]
Voice packet overhead (RTP/UDP/IP)	48	48	
Data packet size (byte)	512	512	
Data packet overhead	48	48	
Voice packet link utilization (%)	10.0%	10.0%	
Data packet link utilization (%)	90.0%	90.0%	
Fixed Delay			
- Serialization delay for voice packet (ms)	3.26	0.55	note [3]
- DSP & CPU processing delay (ms)	12.00	14.00	note [4]
- Packetization Delay (ms)	0.00	N/A	note [5]
Variable Delay			
- Average Voice data contention (ms)	4.57	0.78	note [6]
- Maximum Voice data contention (ms)	9.15	1.55	note [6]
- De-Jitter buffer delay (ms)	N/A	0.00	note [5]
Other Impairments			
- Packet Loss (%)	0.00	0.00	note [5]
Minimum Delay (Fixed Delays) (ms)	15.26	14.55	
Average Delay (Fixed+Average Delays) (ms)	19.84	15.33	
Maximum Delay (Fixed+ Max Delays) (ms)	24.41	16.11	

Fig. 47

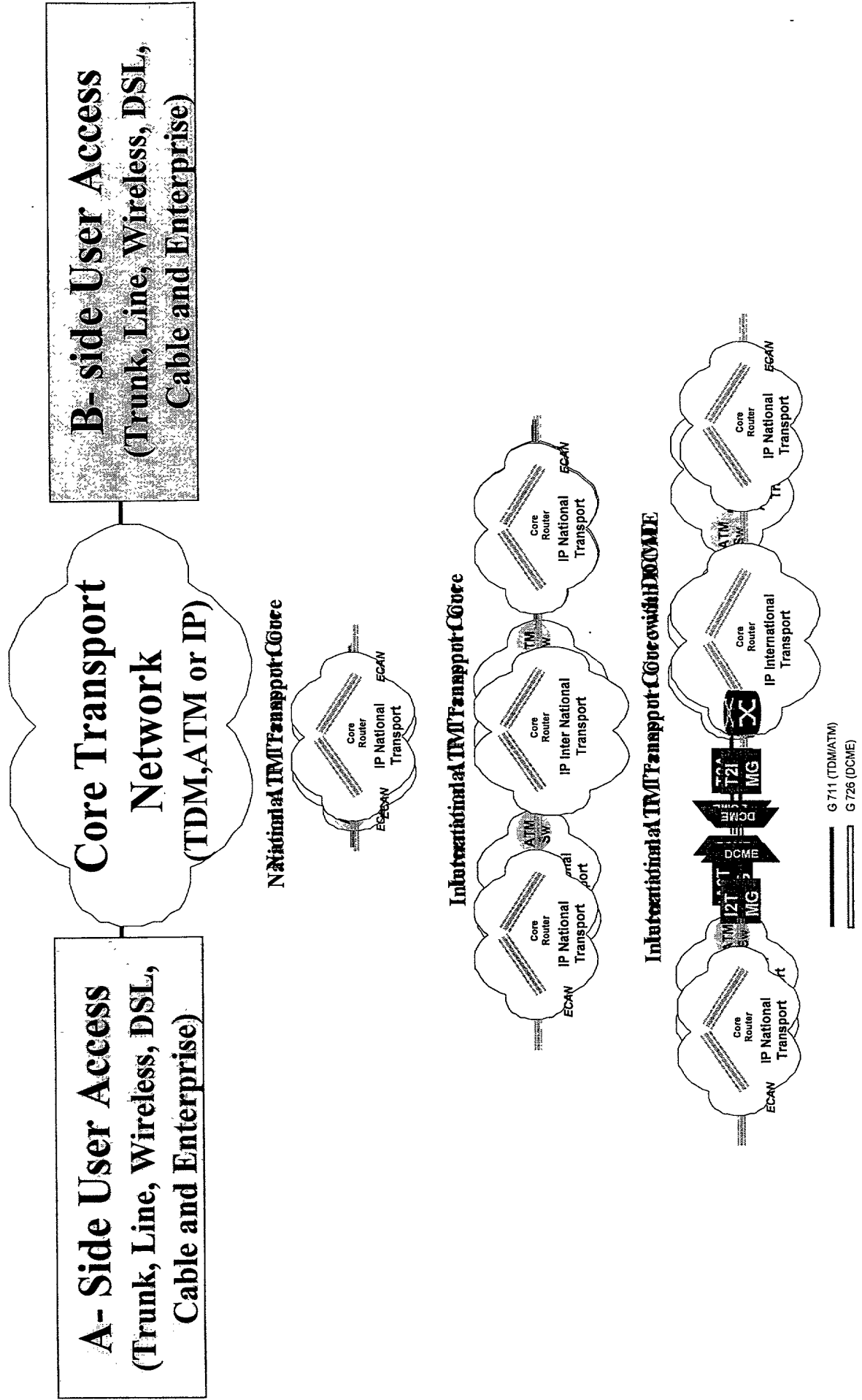


Fig. 48

Total National Transport Distance (km)				Note
	8000 km (IP)	8000 km (ATM)	8000 km (TDM)	
Terrestrial Distance (km)	8000	8000	8000	
Terrestrial propagation Delay @ 5us / km (ms)	40	40	40	From G.114
Submarine Distance (km)	-	-	-	
Submarine propagation Delay @ 6us / km (ms)	-	-	-	From G.114
Number of hop	5	8	4	From I.356, TIA IS-810 G.114
Equipment processing time (ms)	1ms x 5	0.03ms x 8	0.75ms x 4	
Jitter (ms)	note [1]	1.5 note [3]	0	I.356 QoS class 1
Total Delay (ms)	45	41.74	43	Note [2]

International Core Transport delay				Note
	2/500 (IP)	2/500 (ATM)	2/500 (TDM)	
Terrestrial Distance (km)	16000	16000	16000	
Terrestrial Delay @ 5us / km (ms)	80	80	80	
Number of hop	15	19	12	From I.356, TIA IS-810
Equipment processing time per hop	1	0.03	0.75	G.114
Equipment processing time (ms)	15	0.57	9	G.115
Submarine Distance (km)	11500	11500	11500	
Submarine Delay @ 6us / km (ms)	69	69	69	
Jitter (ms)	note [1]	3	0	I.356 QoS class 1
Total Delay (ms)	164	149.57	158	Note [2]

Fig. 49

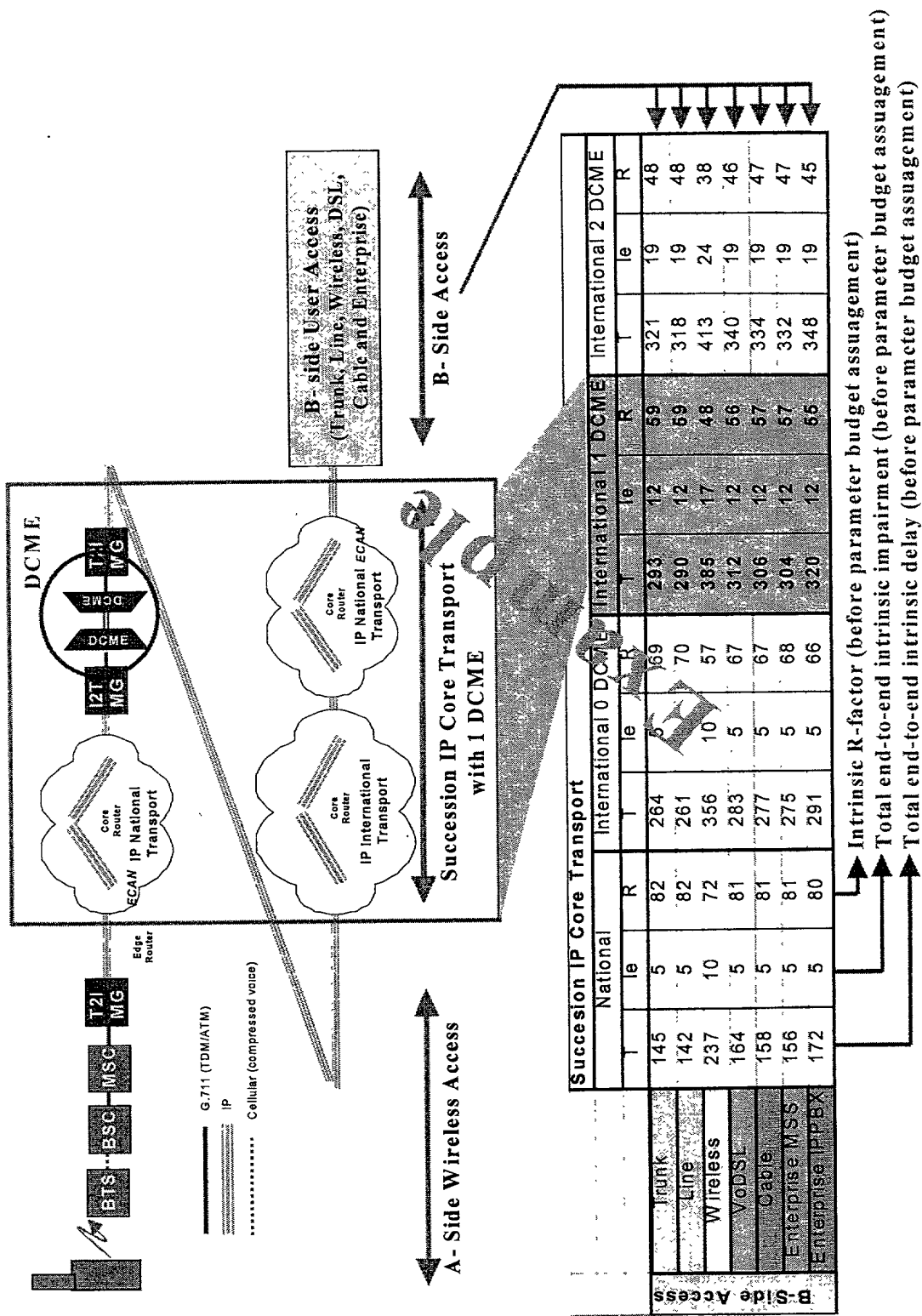


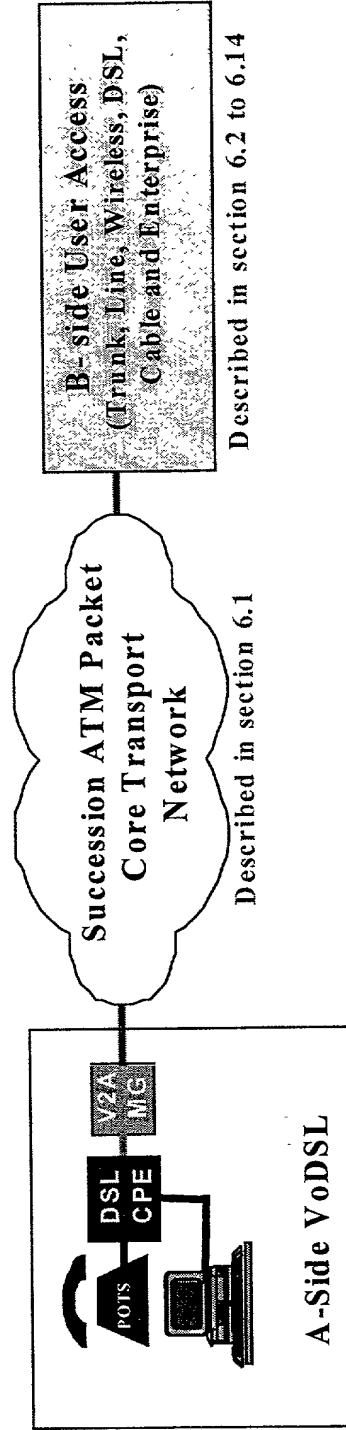
Fig. 50

	ATM Core Transport													
	National			International 0 DCME				International 1 DCME				International 2 DCME		
	T	I	le	T	I	le	R	T	I	le	R	T	I	R
POTS Trunk	47		0	161		0	86		190		77		218	67
POTS Line	45		0	159		0	86		188		77		216	67
Wireless	139		5	253		5	71		282		60		310	49
VoDSL	66		0	180		0	85		209		75		237	64
Cable	61		0	175		0	85		204		75		232	65
Enterprise MSS	48		0	162		0	86		191		77		219	67
Enterprise IPPBX	64		0	178		0	85		207		75		235	64

B-Side Access

Note: The four parameters: packetization delay, delay jitter, codec and packet loss have been set to zero. Those four parameters will be determined based upon the available margin. The margin is determined based on the benchmark comparison of an end-to-end Succession network with the closest benchmark representation of existing networks (PSTN only, mobile to PSTN, or mobile to mobile).

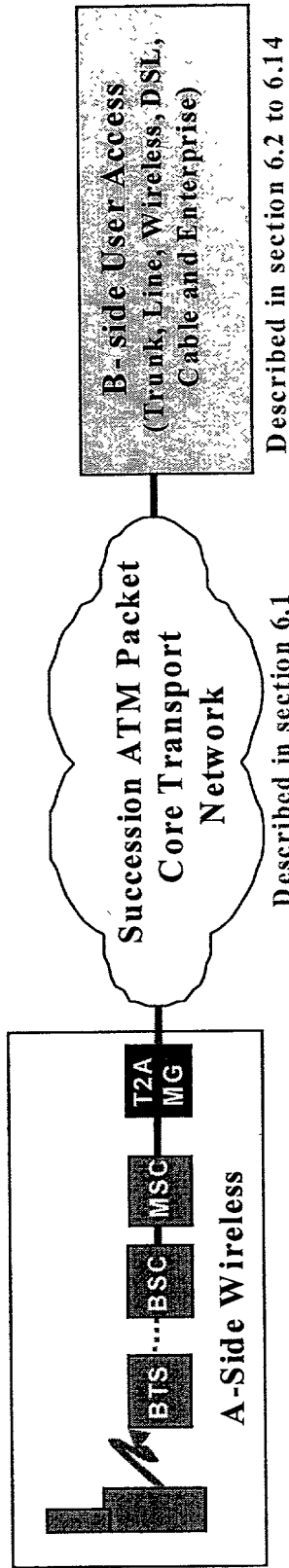
Fig. 51



	ATM Core Transport											
	National			International 0 DCME			International 1 DCME			International 2 DCME		
	I	le	R	I	le	R	I	le	R	I	le	R
POTS Trunk	66	0	87	180	0	85	209	7	75	237	14	64
POTS Line	64	0	88	178	0	85	207	7	75	235	14	64
Wireless	158	5	81	272	5	68	301	12	57	329	19	47
VoDSL	86	0	87	200	0	83	229	7	72	257	14	62
Cable	80	0	87	194	0	83	223	7	73	251	14	62
Enterprise MSS	67	0	87	181	0	85	210	7	75	238	14	64
Enterprise IP/PPBX	84	0	87	198	0	83	227	7	73	255	14	62

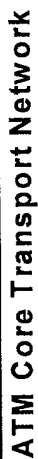
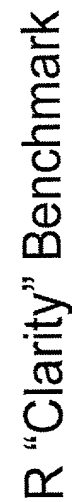
Note: The four parameters: packetization delay, delay jitter, codec and packet loss have been set to zero. Those four parameters will be determined based upon the available margin. The margin is determined based on the benchmark comparison of an end-to-end Succession network with the closest benchmark representation of existing networks (PSTN only, mobile to PSTN, or mobile to mobile).

Fig. 52



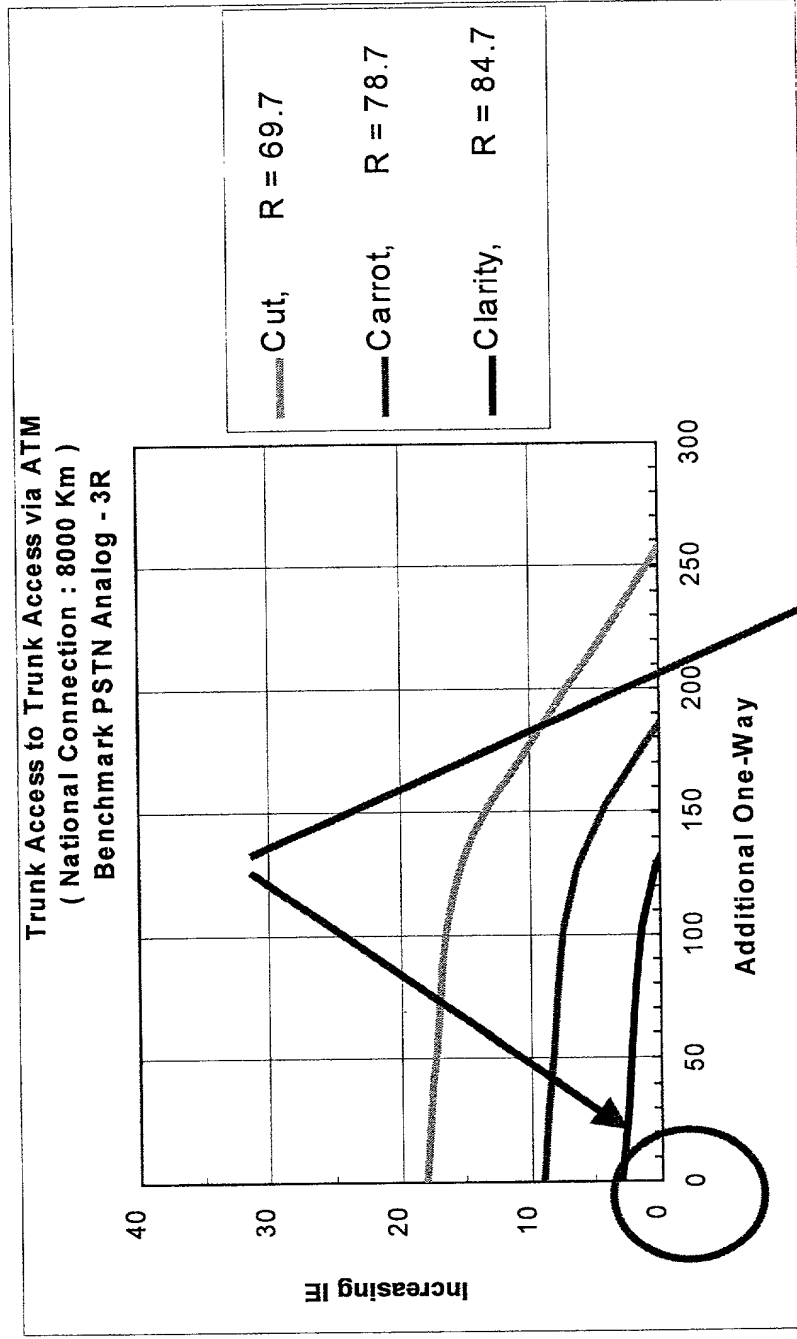
	IP Core Transport											
	National			International 0 DCME			International 1 DCME			International 2 DCME		
	T	Ie	R	T	Ie	R	T	Ie	R	T	Ie	R
POTS Trunk	145	5	86	264	5	74	293	12	63	321	19	53
POTS Line	142	5	86	261	5	74	290	12	64	318	19	53
Wireless	237	10	72	356	10	57	385	17	48	413	24	38
VoDSL	164	5	85	283	5	71	312	12	61	340	19	51
Cable	158	5	85	277	5	72	306	12	62	334	19	52
Enterprise MSS	156	5	85	275	5	72	304	12	62	332	19	52
Enterprise IPPBX	172	5	84	291	5	70	320	12	60	348	19	50

Note: The four parameters: packetization delay, delay jitter, codec and packet loss have been set to zero. Those four parameters will be determined based upon the available margin. The margin is determined based on the benchmark comparison of an end-to-end Succession network with the closest benchmark representation of existing networks (PSTN only, mobile to PSTN, or mobile to mobile).

[illegible]

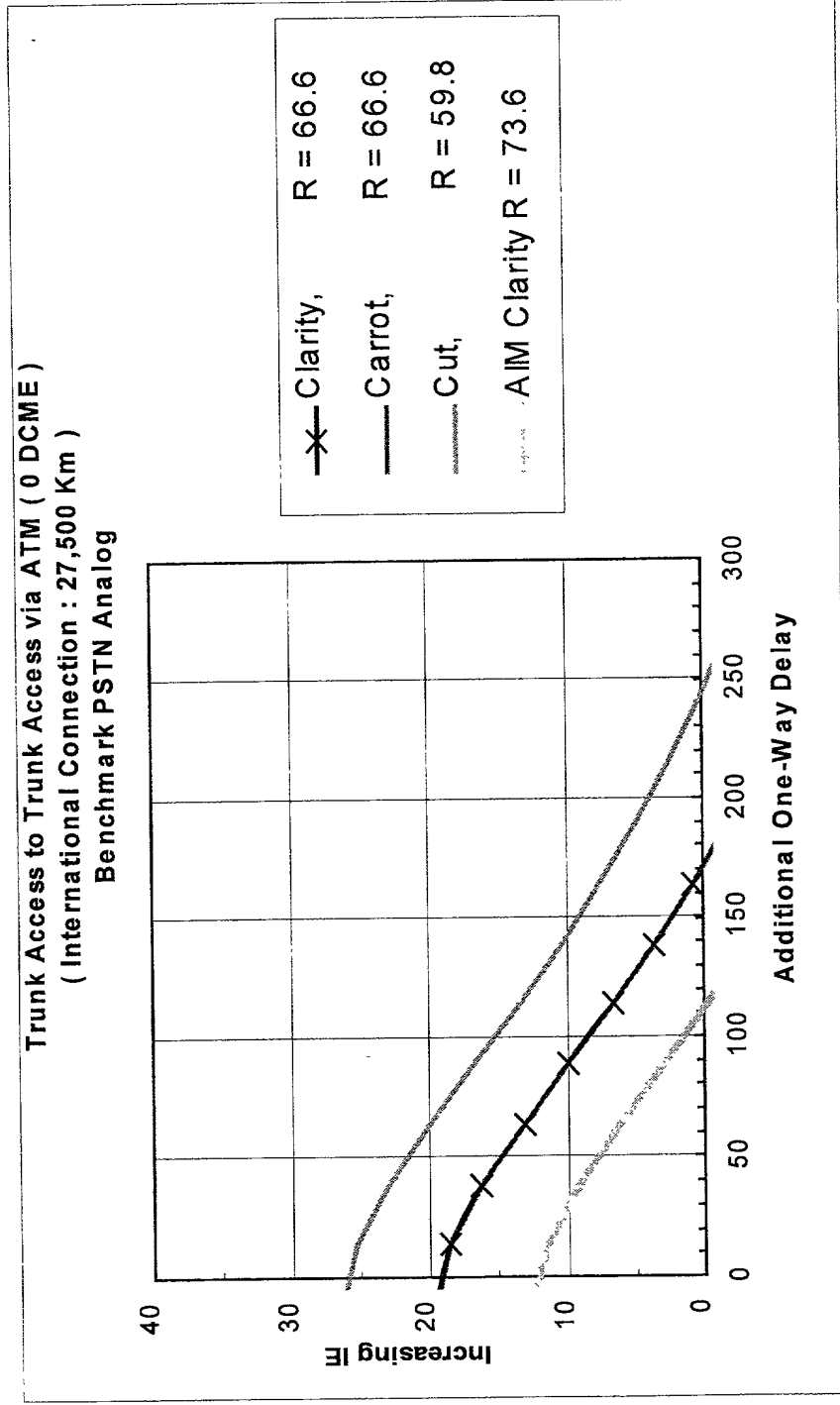
Note: In red indicates the worst case access scenario with the smallest available budget

Fig. 54



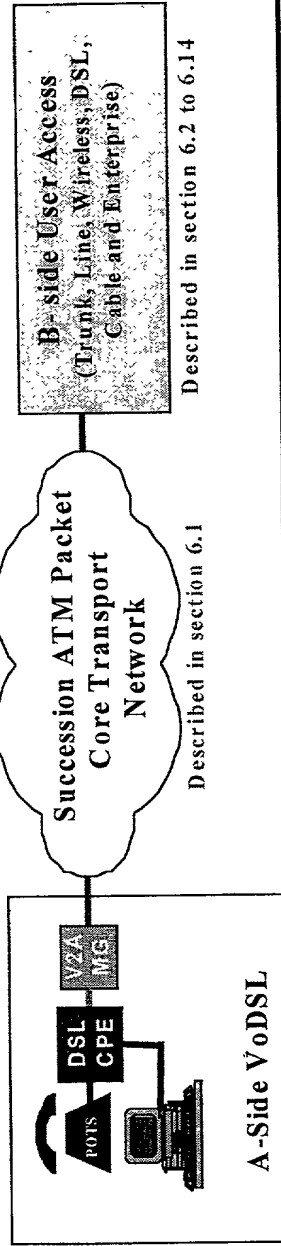
le Budget =	3	9	18
Delay Budget =	130	186	257

Fig. 55

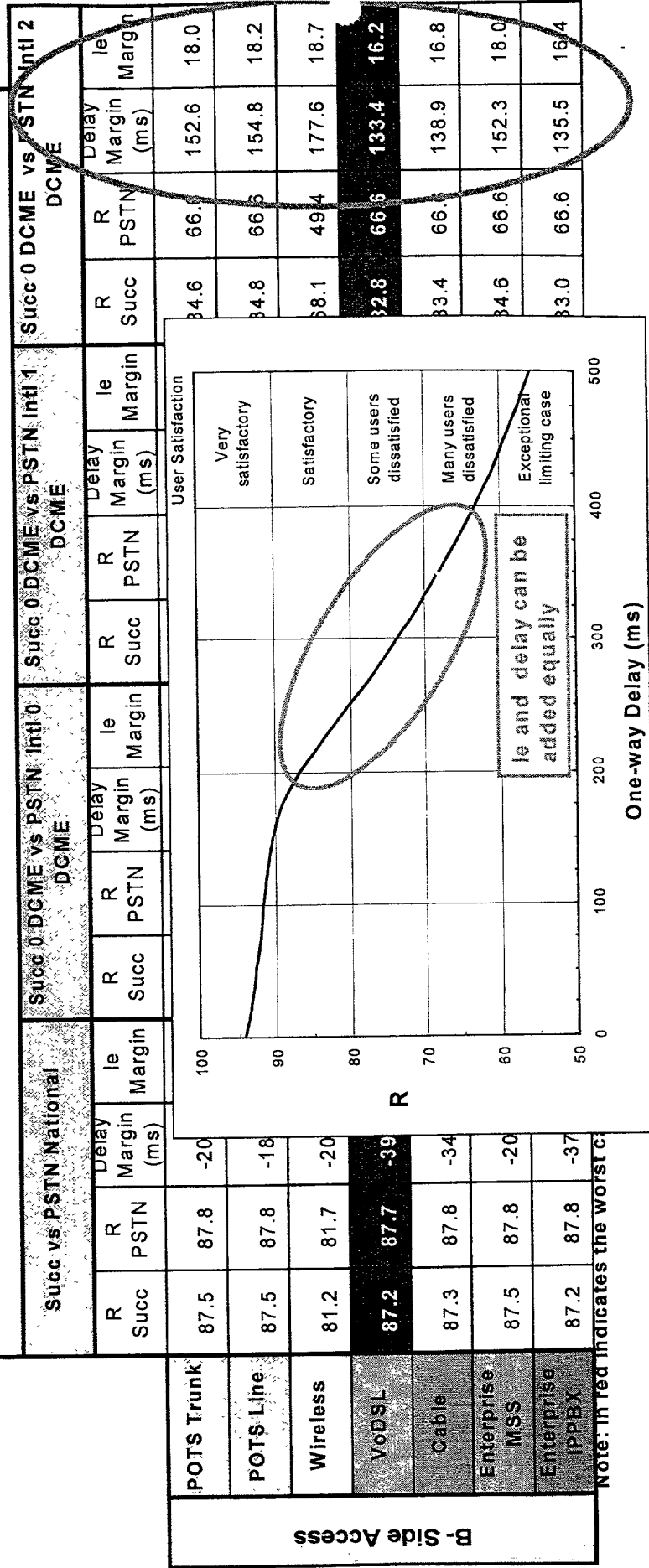


Ie Budget =	12.07	19.07	19.07	25.87
Delay Budget	110.9	171.5	171.5	244.4

Fig. 56



ATM Core Transport Network



Note: in red indicates the worst case

Fig. 57

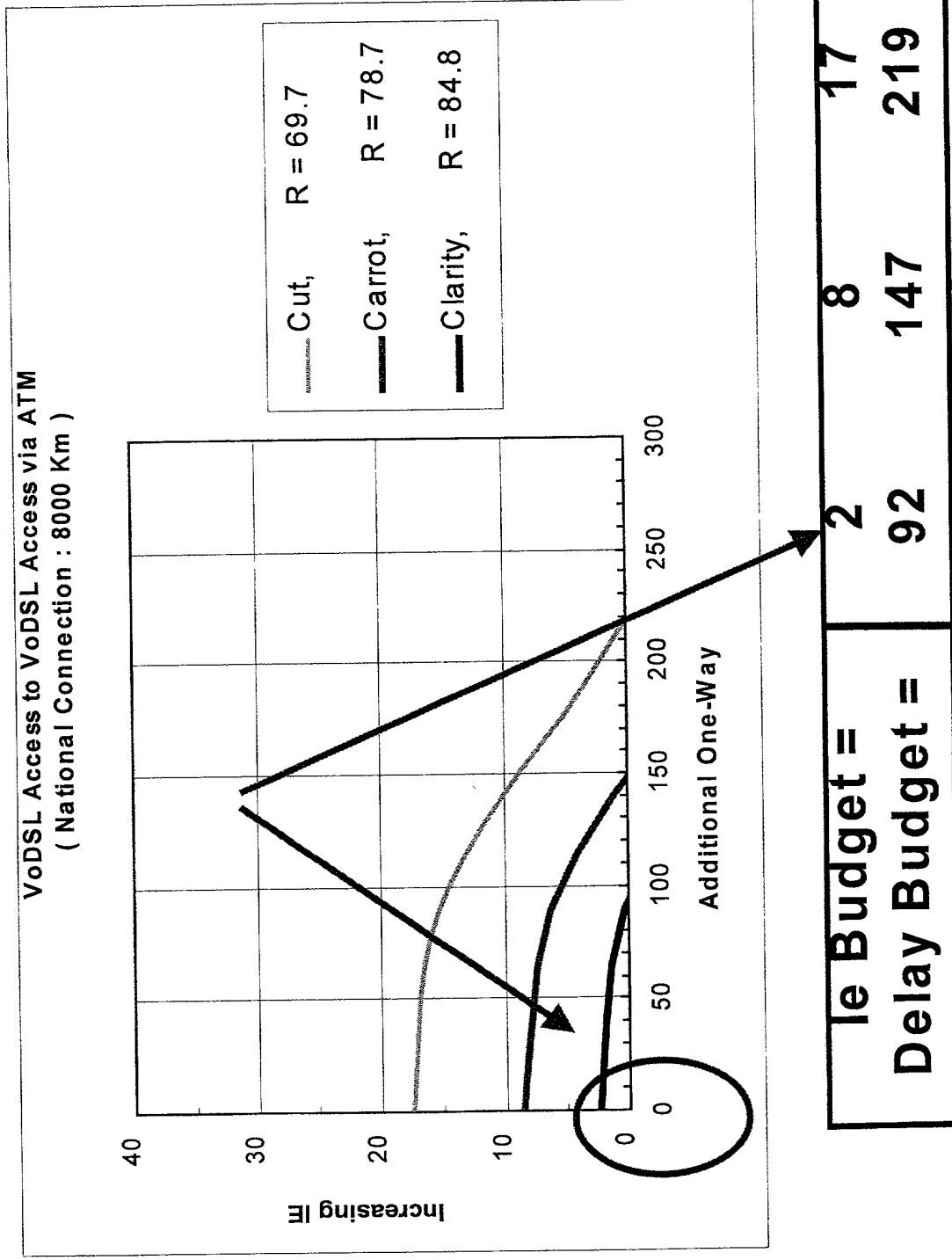
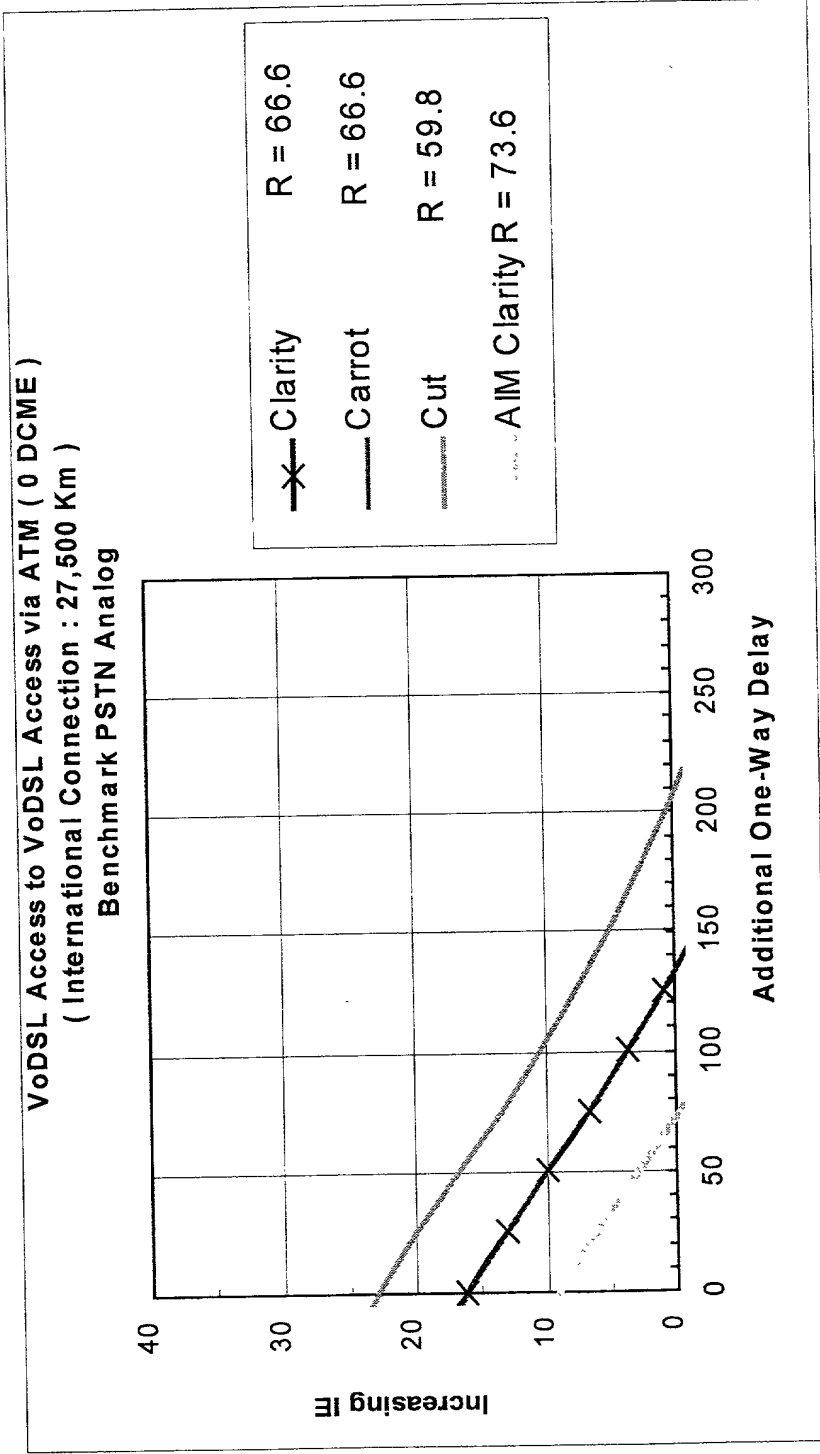
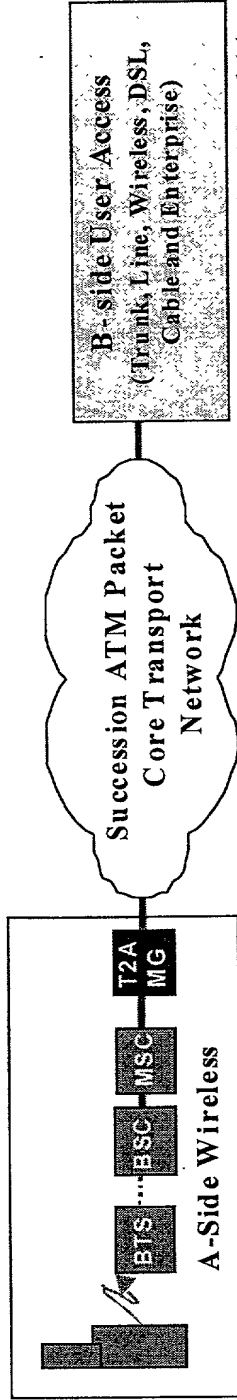


Fig. 58



le Budget = Delay Budget =	9.207	16.21	16.21	23.01
	72.54	133.1	133.1	206

Fig. 59



Described in section 6.1

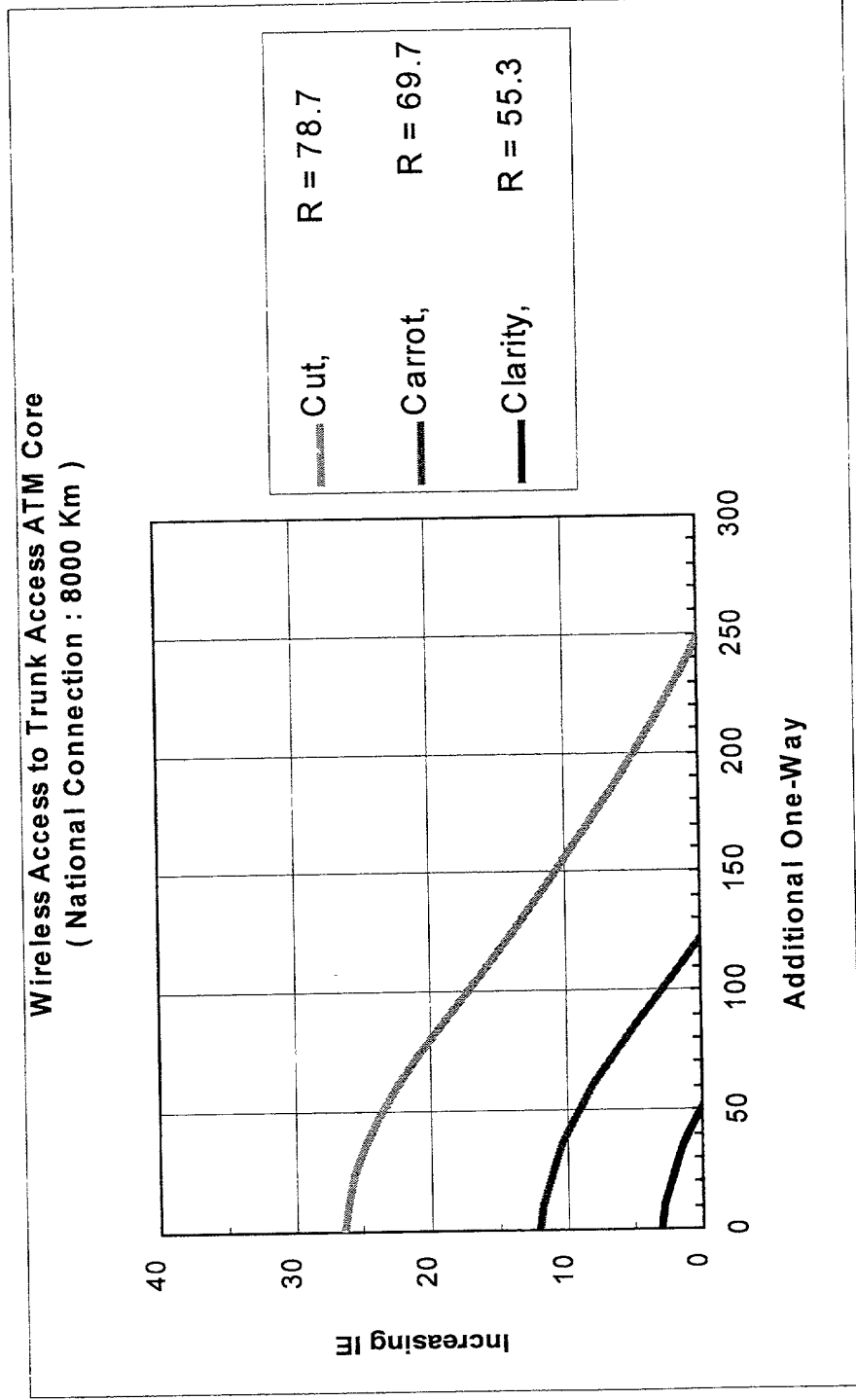
Described in section 6.2 to 6.14

ATM Core Transport Network

ATM Core Transport Network																
	Succ vs PSTN National			Succ 0 DCME vs PSTN Intl 0 DCME				Succ 0 DCME vs PSTN Intl 1 DCME				Succ 0 DCME vs PSTN Intl 2 DCME				
	R Succ	R PSTN	Delay Margin (ms)	le Margin	R Succ	R PSTN	Delay Margin (ms)	le Margin	R Succ	R PSTN	Delay Margin (ms)	le Margin	R Succ	R PSTN	Delay Margin (ms)	le Margin
POTS Trunk	81.8	81.7	-1.2	0.1	70.7	70.6	-0.2	0.1	70.7	59.8	91.8	10.9	70.7	49.4	196.8	21.3
POTS Line	81.8	81.7	1.0	0.1	71.0	70.6	2.0	0.4	71.0	59.8	94.0	11.2	71.0	49.4	199.0	21.6
Wireless	72.7	72.7	-0.2	0.0	58.5	58.3	0.8	0.2	58.5	48.5	17.8	10.0	58.5	39.0	192.8	19.5
VoDSL	81.2	81.7	-20.4	-0.5	68.1	70.6	-19.4	-2.5	68.1	59.8	72.6	8.3	68.1	49.4	177.6	18.7
Cable	81.4	81.7	-14.9	-0.3	68.8	70.6	-13.9	-1.8	68.8	59.8	78.1	9.0	68.8	49.4	183.1	19.4
Enterprise MSS	81.8	81.7	-1.6	0.1	70.6	70.6	-0.5	0.0	70.6	59.8	91.5	10.8	70.6	49.4	196.5	21.2
Enterprise IP/PPBX	81.2	81.7	-18.4	-0.5	68.4	70.6	-17.3	-2.2	68.4	59.8	74.7	8.6	68.4	49.4	179.7	19.0

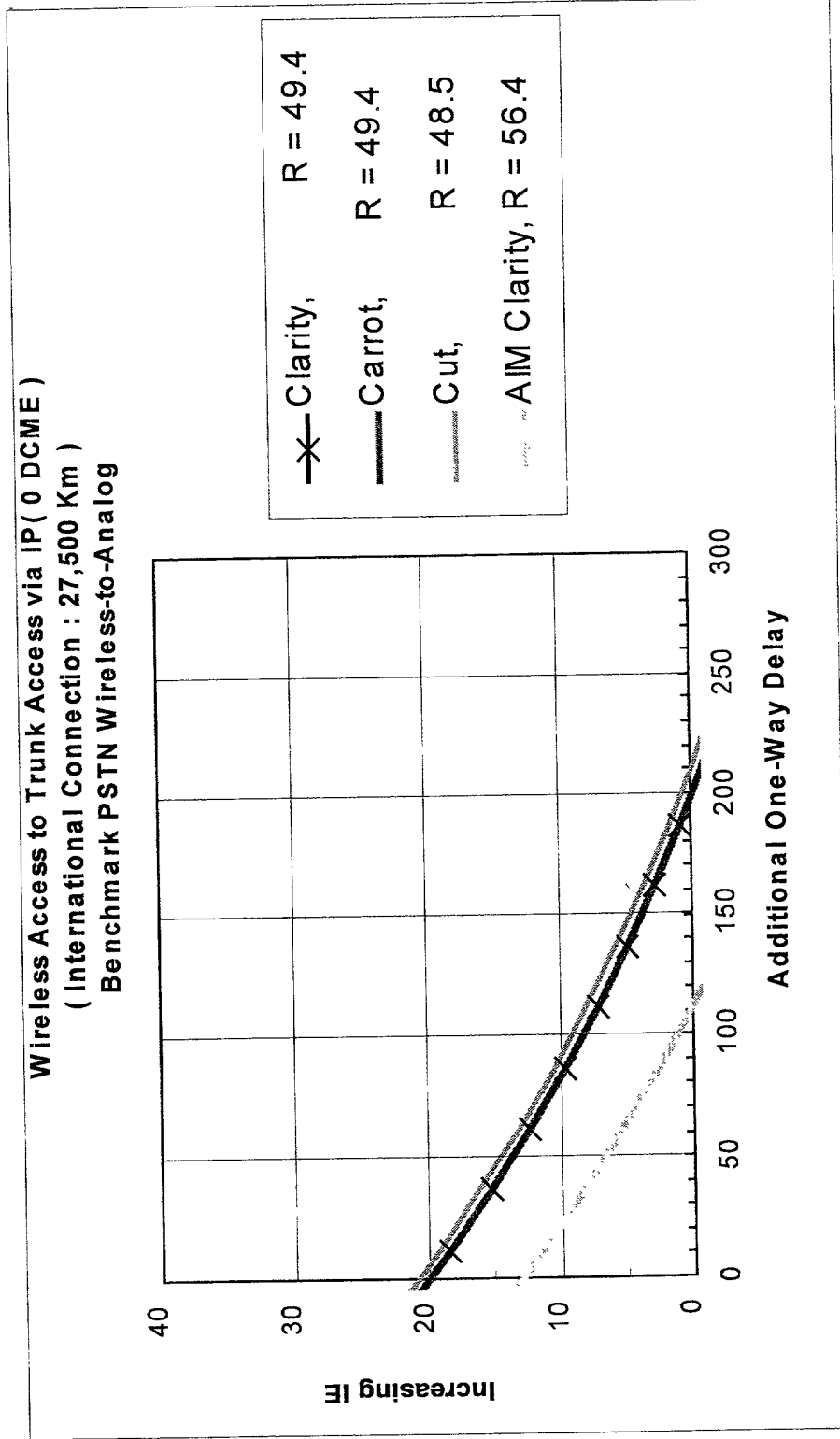
Note: in red indicates the worst case access scenario with the smallest available budget

Fig. 60



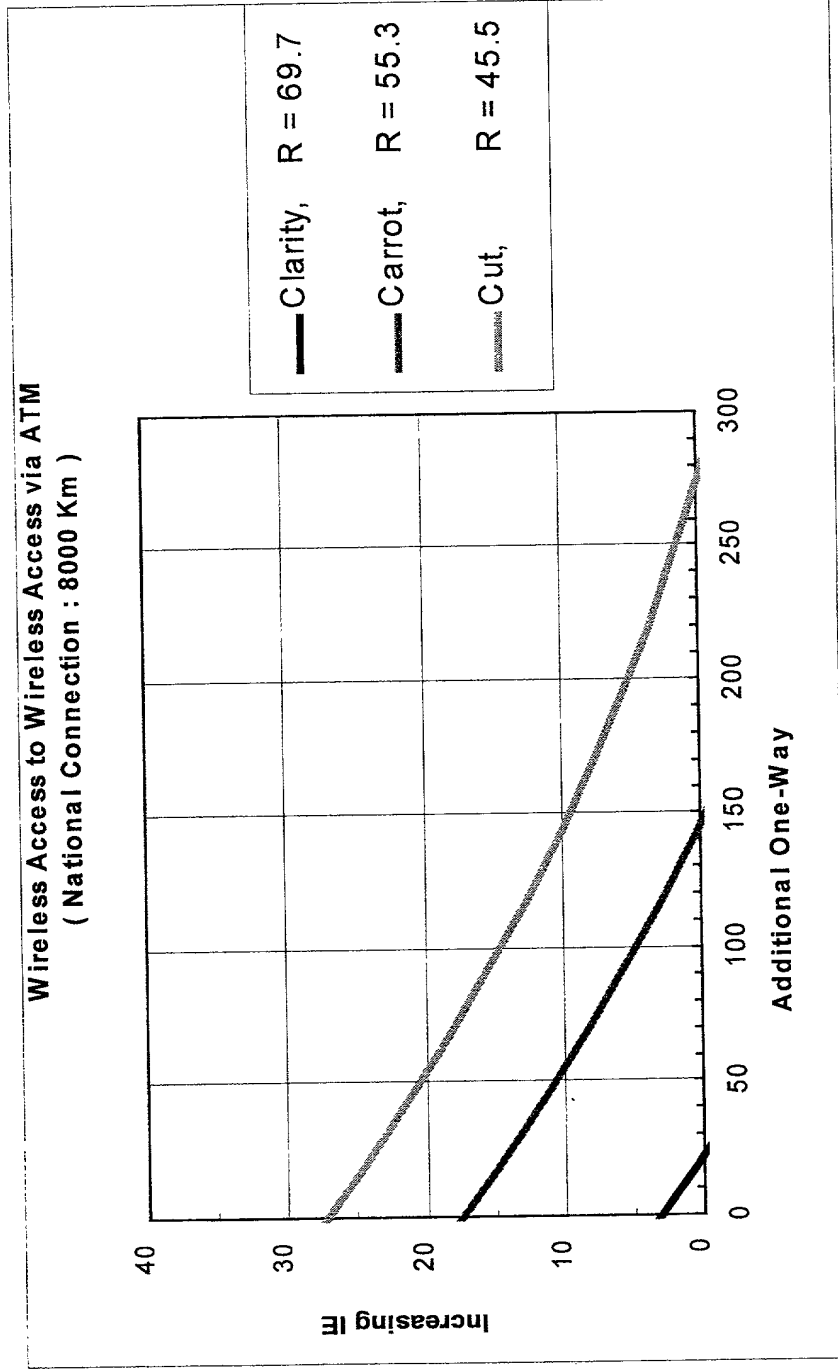
le Budget =	3	12	26
Delay Budget =	51	121	249

Fig. 61



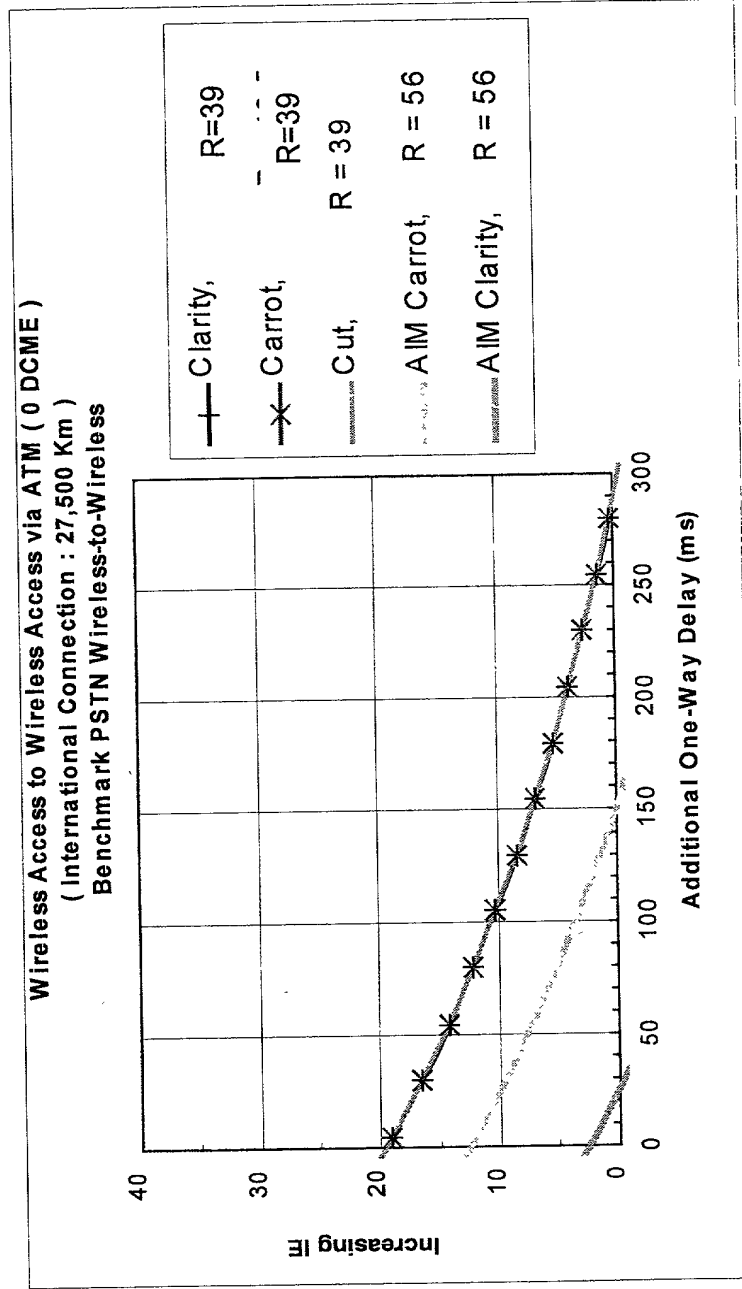
le Budget =	12.91	20	20	21
Delay Budget =	112.4	197	197	210

Fig. 62



Delay Budget =	3.004	17.34	27.14
le Budget =	21.97	145.8	273.1

Fig. 63



le Budget =	2	12	19	19	19
	25	151	181	248	289

Fig. 64

Rank	Codec	E-model Impairment Factor (Ie)	Estimated implementation delay (ms)	Note
1	G.711 at 64 kb/s	0	0.125	PCM
2	G.726 at 32 kb/s with Synchronizing Coding	7	0.250	ADPCM
3	GSM-EFR	5	40	GSM
4	IS-733	*	40	
5	G.728 at 16 kb/s	7	1.250	
6	G.729/G.729A at 8 kb/s	10/11	25	
7	IS-641	6	40	TDMA
8	G.723.1 at 6.3 kb/s (not recommended)	15	30	Soft Phone

Fig. 65

Codec		packetization delay (ms)	max packet loss (%)	le due to packet loss
type	Codec le			
G.711	0	10	0%	0
G.711	0	20	0%	0
G.726(1)	7	10	0%	0

1. This codec is only really suitable for international

Fig. 66

Codec		packetization delay (ms)	max packet loss (%)	le due to packet loss
type	Codec le			
G.711	0	10	0%	0
G.711	0	20	0%	0
G.711	0	40	0%	0
G.726	7	10	0%	0
G.726	7	20	0%	0
G.726	7	40	0%	0
G.711	0	10	1%	5
G.711	0	20	1%	5

Fig. 67

Codec		packetization delay (ms)	max packet loss (%)	le due to packet loss
type	Codec le			
G.711	0	10	0%	0
G.711	0	20	0%	0
G.711	0	40	0%	0
G.726	7	10	0%	0
G.726	7	20	0%	0
G.726	7	40	0%	0
G.729	11	10	0%	0
G.729	11	20	0%	0
G.729	11	40	0%	0
G.711	0	10	1%	5
G.711	0	20	1%	5
G.711	0	40	1%	5
G.726	7	10	1%	2
G.726	7	20	1%	4
G.726	7	40	1%	8
G.729	11	10	1%	2
G.729	11	20	1%	4

Fig. 68

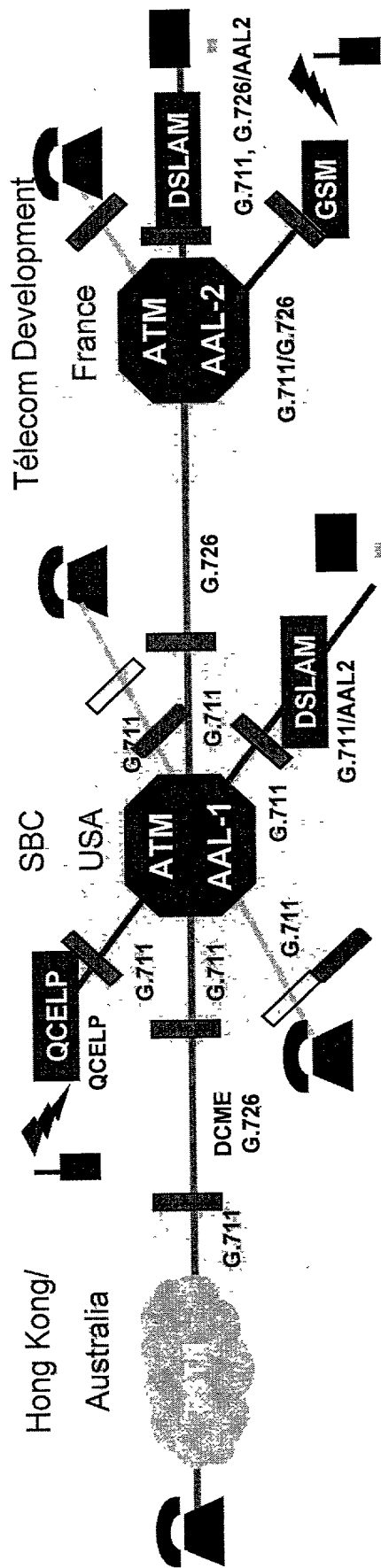


Fig. 69

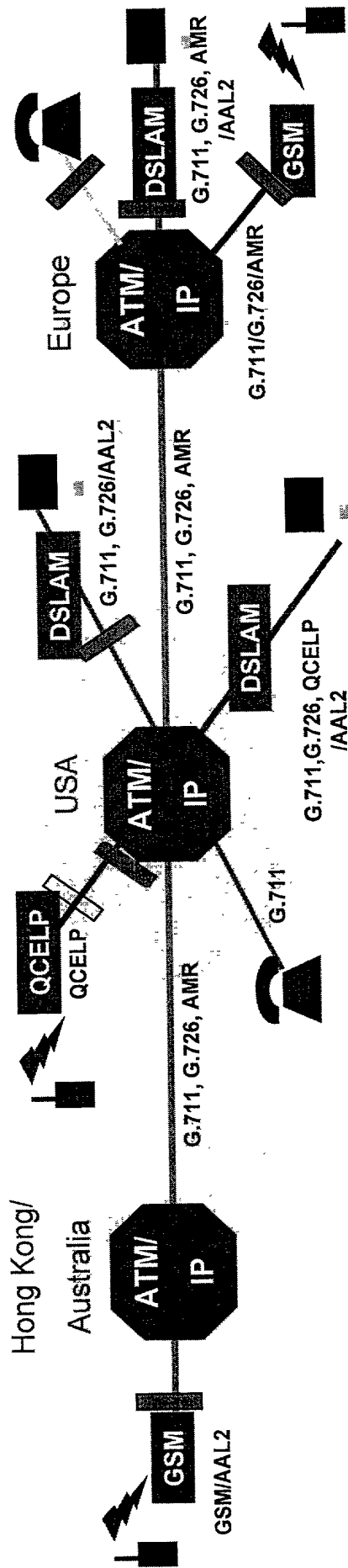


Fig. 70

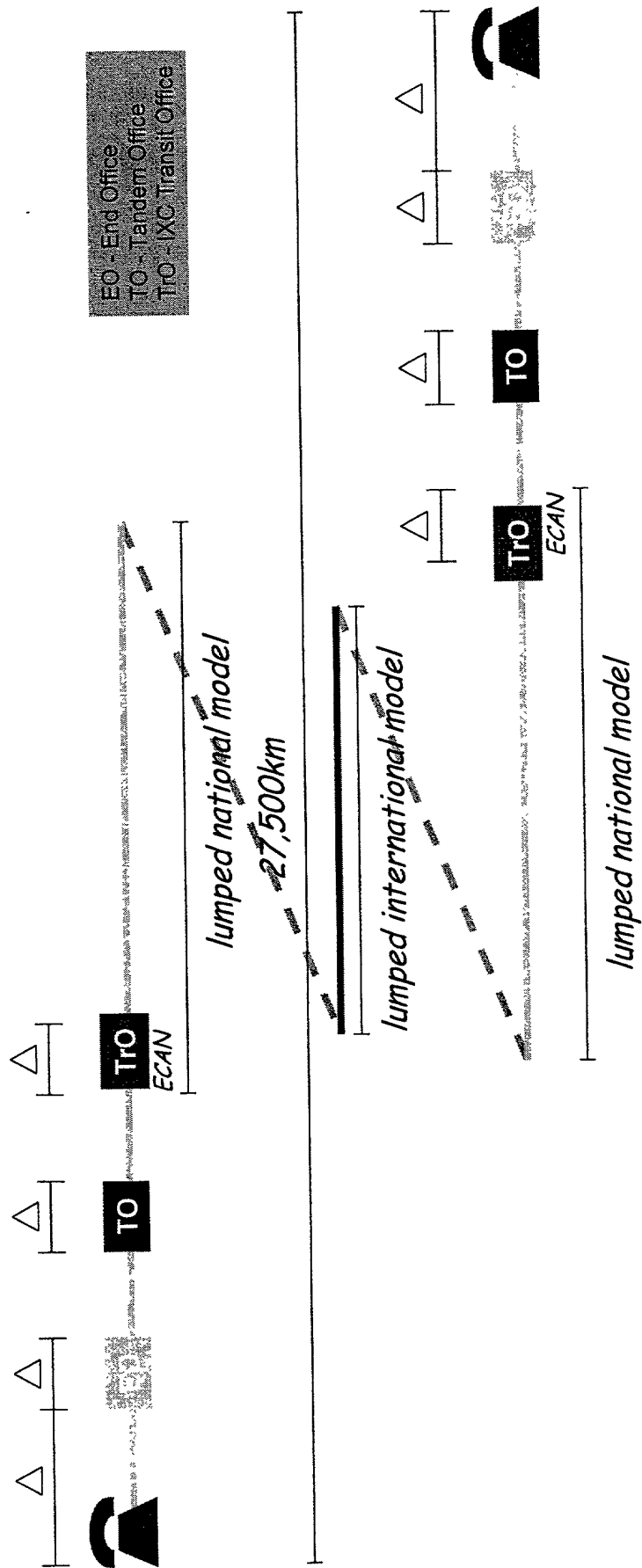


Fig. 71

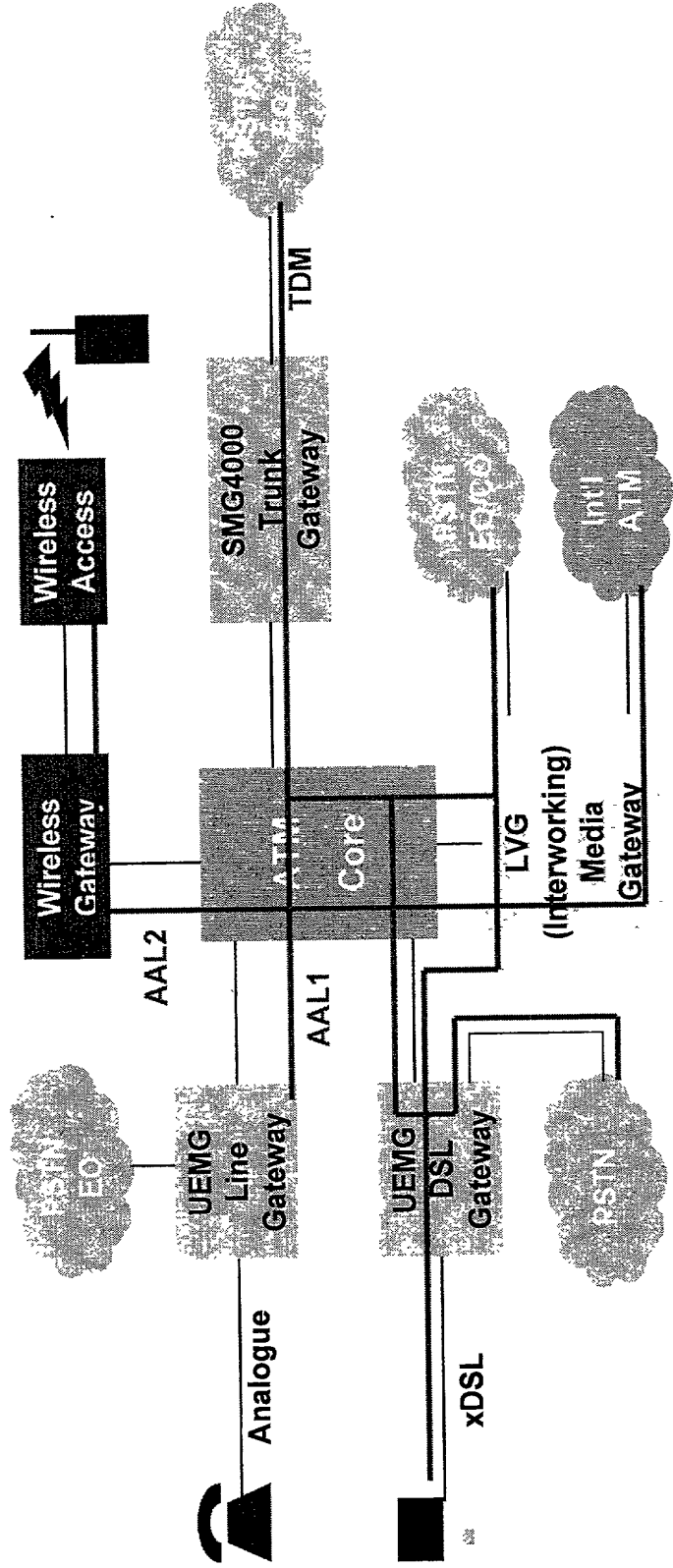
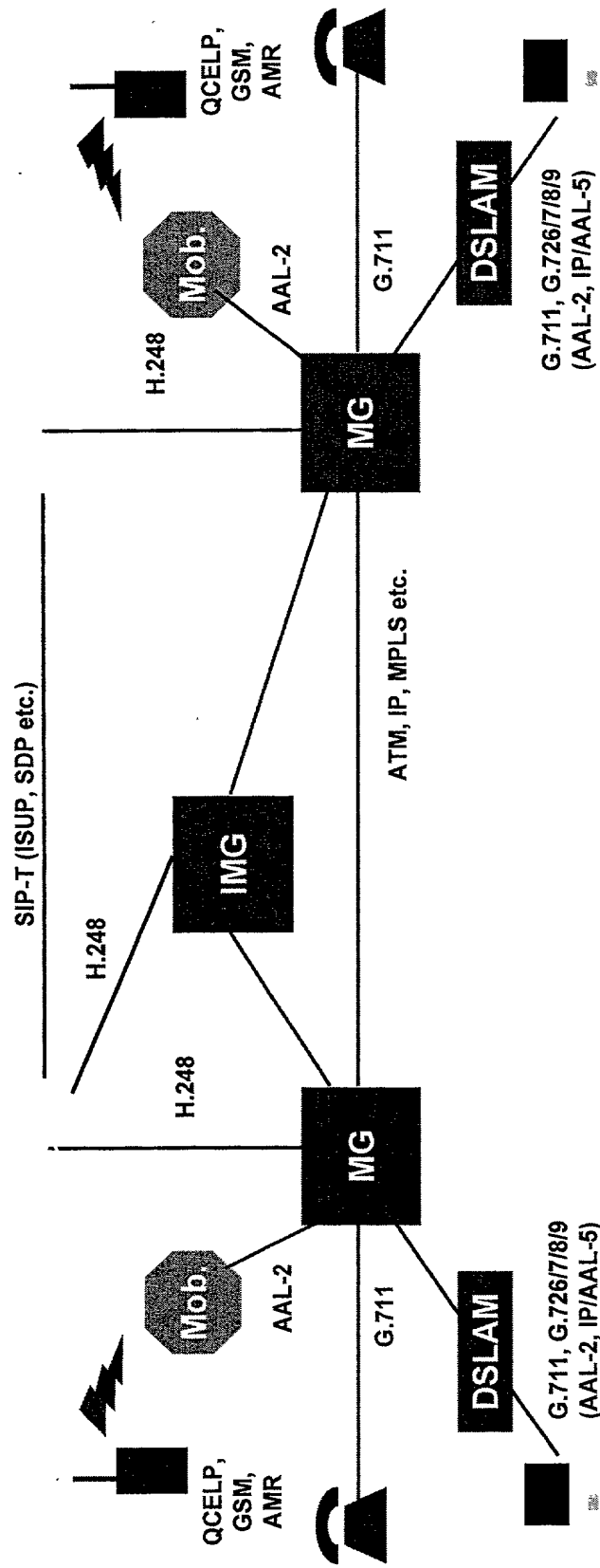


Fig. 72



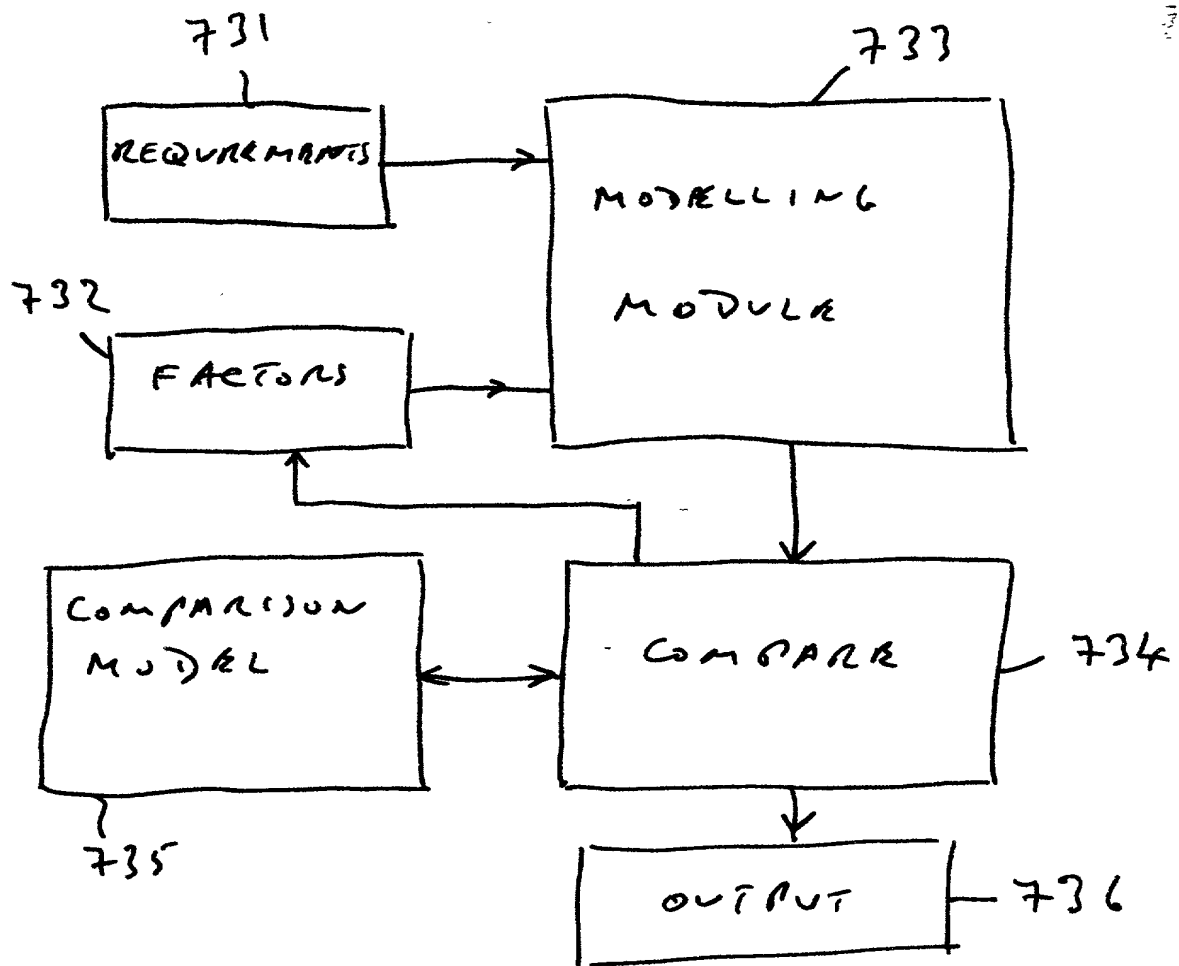


Fig 73